ESSENTIAL FISH HABITAT ASSESSMENT
NAVAL ACTIVITY PUERTO RICO

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

°	Degrees
°C	Degree Celsius
°F	Degree Fahrenheit
ac	Acre(s)
CFMC	Caribbean Fishery Management Council
cm	Centimeter(s)
DON	Department of the Navy
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
ENE	East-Northeast
FMP	Fishery Management Plan(s)
ft	Feet
GMI	Geo-Marine, Inc.
ha	Hectare(s)
HAPC	Habitat Areas of Particular Concern
Hz	Hertz
in	Inch(es)
km	Kilometer(s)
kph	Kilometer(s) Per Hour
kt	Knot(s)
LPI	Liner Point Intercept
m	Meter(s)
m^{-2}	Per Square Meter
mi	Mile(s)
mph	Mile(s) Per Hour
MSFCMA	Magnuson-Stevens Fishery Conservation Management Act
NAPR	Naval Activity Puerto Rico
NM	Nautical Mile(s)
NMFS	National Marine Fisheries Service
NSRR	Naval Station Roosevelt Roads
ppt	Parts Per Thousand
SWMU	Solid Waste Management Unit
SAV	Submerged Aquatic Vegetation
U.S.	United States
USFWS	United States Fish and Wildlife Service

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1.0 INTRODUCTION AND PURPOSE

This document is part of the consultation process with the NMFS called for by the MSFCMA and its implementing rules.

The Magnuson-Stevens Fishery Conservation Management Act (MSFCMA) (16 U.S.C. § 1801-1882) established regional fishery management councils and mandated that fishery management plans (FMP) be developed to responsibly manage exploited fish and invertebrate species in Federal waters of the United States (U.S.). When Congress reauthorized this act in 1996, several reforms and changes were made. One change was to charge the National Marine Fisheries Service (NMFS) with designating and conserving essential fish habitat (EFH) for species managed under existing FMPs. This was intended to minimize, to the extent practicable, any adverse effects on habitat caused by fishing or non-fishing activities, and to identify other actions to encourage the conservation and enhancement of such habitat.

Geo-Marine, Inc. (GMI) prepared this EFH assessment for the Natural and Cultural Resources Planning Section of the Naval Facilities Engineering Command, Atlantic. The purpose of this EFH assessment is to evaluate whether or not the Local Redevelopment Authority's (LRA's) Reuse Plan developed for Naval Station Roosevelt Roads (NSRR), Puerto Rico, is likely to cause an adverse effect on EFH or on species managed by the Caribbean Fishery Management Council (CFMC) (CBRE 2004).

Pursuant to the United States Department of Defense Appropriations Act of Fiscal Year 2004 (Public Law 108-87), the United States Department of the Navy (Navy) has closed NSRR in Puerto Rico. Section 8132 (a) of Public Law 108-87 states, "Notwithstanding . . . any other provision of law, the Secretary of the Navy shall close Naval Station Roosevelt Roads, Puerto Rico, no later than 6 months after enactment of this Act." Accordingly, on March 31, 2004, NSRR ceased operations as a Naval Station. The base was re-designated as Naval Activity Puerto Rico (NAPR) to maintain a Navy presence and associated security during the disposal process (**Figure 1**). Public Law 108-87, Section 8132(b) further states, "The closure provided for in subsection (a), and subsequent disposal, shall be carried out in accordance with the procedures and authorities contained in the Defense Base Closure and Realignment Act of 1990 (title XXIX of Public Law 101-510; 10 U.S.C. 2687 note)."

The NAPR consists of an 8,660 acre (ac) (3,506 hectares [ha]) property located at the eastern tip of mainland Puerto Rico near the municipality of Ceiba (**Figure 1**). NAPR was a military facility from 1943 through March 31, 2004. It served as a mobilization point and a support facility. It included a harbor and marina, an airfield, munitions storage facilities, and an area for armed forces training. There are extensive mangrove forests and wetlands along the north, east, and south edges of NAPR (DON 1998). Coral reefs and associated organisms, and seagrass beds border the NAPR coastline (NOAA/NOS 2001; Reid et al. 2001).

The NAPR property roughly consists of 8,306 ac (3,363 ha) on mainland Puerto Rico and 354 ac (143 ha) on three islands (Isla Piñeros, Isla Piñerita, and Isla Cabeza de Perro) (Isla Cabras being connected to the mainland by a causeway is considered part of the mainland) (**Figure 1**). Ensenada Honda, located in the center of the site, is a large protected harbor. To the north of Ensenada Honda is Bahia Puerca, a smaller protected bay within which is the islet, Isla Cabritas.

The area available for the LRA's Reuse Plan is limited to 3,868 ac (1,569 ha). The remainder of the property consists of wetlands, the 100-year floodplain, and areas with a slope gradient greater than 15%. The LRA's Reuse Plan includes a plan to preserve 3,450 ac (1,399.7 ha) of mangrove forests and wetlands.

The LRA's Reuse Plan proposes the reuse of existing infrastructure and facilities and the improvement/construction of new infrastructure and facilities (**Figure 2**). In summary, the LRA's Reuse Plan consists of the following thirteen items:

(1) Reuse of the airfield as a passenger and cargo facility
(2) Reuse of harbor facilities as a passenger and light cargo ferry facility

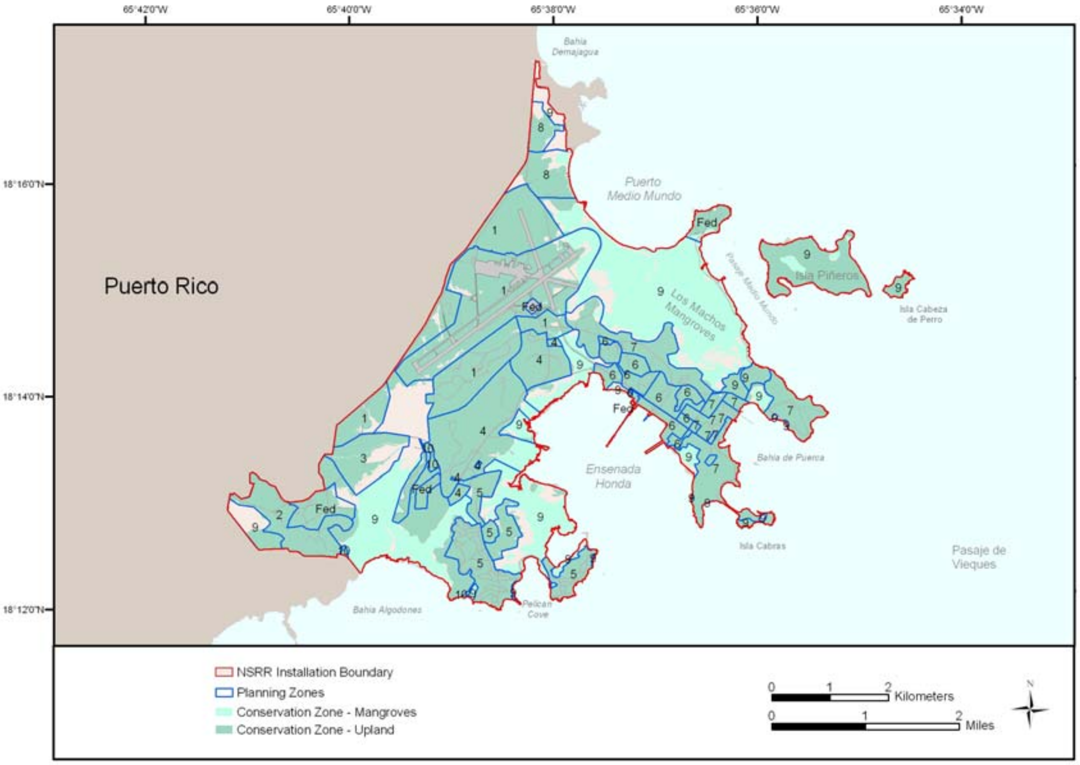

Figure 1. Location Map of Naval Activity Puerto Rico (NAPR) (formerly Naval Station Roosevelt Roads [NSRR]) and Proposed Local Reuse Authority's (LRA) Reuse Plan (CBRE 2004).

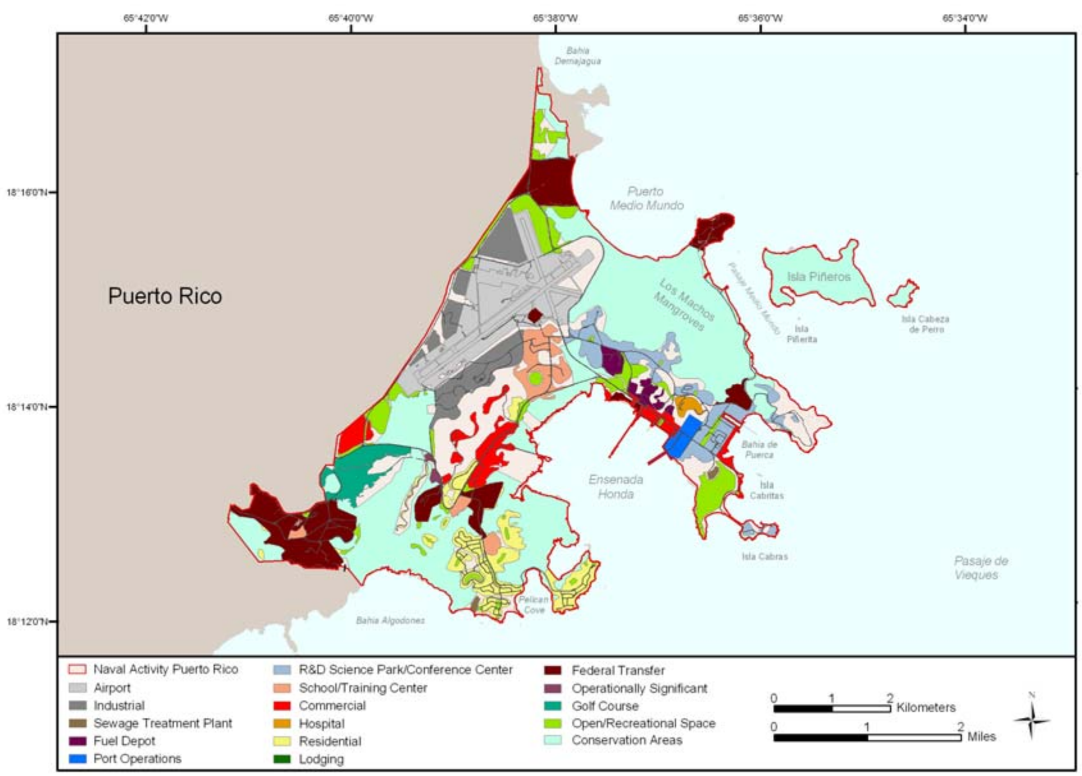

Figure 2. Proposed Reuse of Existing Infrastructure and Facilities and Development as Presented in the LRA's Reuse Plan (CBRE 2004).

(3) Reuse the NSRR hospital as a civilian hospital
(4) Reuse and expansion of the NSRR 9-hole golf course
(5) Reuse of the NSRR elementary school as a public middle/high school
(6) Reuse of the NSRR middle/high school campus as a private school
(7) Reuse of NSRR academic, residential, and support facilities as a university campus
(8) Development of a science park including research and development facilities
(9) Development of industrial and commercial facilities
(10) Development of facilities supporting water-oriented commercial and recreational activities
(11) Development of residential areas
(12) Expansion/Improvement of the existing Morale, Welfare, and Recreation marina
(13) Potential resort development

Implementation of the proposed action, the disposal of NAPR property to federal and other future property owners, would not in and of itself result in impacts to EFH, managed and associated species, and protected species.

2.0 DESCRIPTION OF PROPOSED ACTION

The proposed action is the disposal of the NAPR. The LRA's Reuse Plan presents a follow-on action by a third party including a comprehensive approach to land development and conservation under a single ownership (CBRE 2004).

2.1 PROPOSED LAND USE

The LRA's Reuse Plan defines nine distinctive zones within which reuse and new development would occur. Short-term and long-term reuse and development activities that have the potential to affect EFH and species managed by the CFMC are potentially contained both on inland and water front property.

Reuse and development activities in the zones that are immediately adjacent to the NAPR waterfront possibly have the greatest potential of causing adverse effects on EFH and on species managed by the CFMC. These waterfront zones are:

- Zones 5B and 5C both master planned residential zones.
- Zones 6B and 6C both planned for an expanded recreational boat marina and water-oriented commercial activities.
- Zone 6E reuse of the area as a passenger/cargo ferry terminal.
- Zone 7 will include the science park and conference center.

Zones inland of the NAPR waterfront are perhaps less likely to be the source of reuse and development activities that could cause adverse effects on EFH and on species managed by the CFMC. Yet, these "inland" zones are within a relatively short distance (2.2 miles [mi], 3.5 kilometers [km]) of the waterfront.

3.0 NAVAL ACTIVITY PUERTO RICO: ENVIRONMENTAL SETTING

3.1 CLIMATE

The climate at NAPR is characterized as warm and humid with frequent rainfall throughout the year. The annual temperature amplitude is 4 degrees (°) Celsius (C) with August being the warmest month (82.0°F, 27.8 °C) and February the coldest (75.0°F, 23.9 °C) (NLMOC 2000). The dominant climate force in NAPR is the trade winds. Two weather patterns produce significant rainfall. Winds known as "easterly waves" occur every five to seven days from May through November and produce thunderstorm activity. Then from November to May, cold fronts that occur every seven to ten days result in one to two days of rainfall and overcast skies. The lowest amount of rainfall occurs in February (2.5 inches [in] per month, 6.4 centimeters [cm] per month). May and October usually have the most rainfall (7.5 in, 19.1 cm) (NLMOC

2000). Average annual rainfall at NAPR is 58 in (147 cm) (DON 1998). Areas immediately west and north of NAPR typically receive 69 to 100 in (177 to 254 cm) of rainfall per year. These areas influence the Rio Daguao watershed, the lower part of which encompasses the western boundary of NAPR (DON 1998).

Dominant trade winds cause wind direction to be mostly of the east-northeast (ENE) throughout the year. From November through January, winds out of the ENE average 7 to 9 knots (kt) (maximum wind speed: 40 to 47 kt). From February through October, winds out of the east average 6 to 8 kt (maximum wind speed: 36 to 76 kt) (NLMOC 2000).

Hurricane season is June through November, with August through October being the most active months. From 1946 through 1999, 39 cyclones passed close to NAPR (11 in August, 19 in September) (NLMOC 2000). An average of two tropical storms per year occurs in the area (up to 85 miles per hour [mph], 137 kilometers per hour [kph] winds) (DON 1998).

3.2 HYDROGRAPHY

Sea surface transport (0 to 49 feet [ft], 0 to 15 meter [m] water depth range) off NAPR is primarily driven by the trade winds out of the east and ENE (NLMOC 2000). Sea surface currents are secondarily modified by daily tidal currents. Flood tidal surface currents intensify the wind driven sea surface transport (average maximum speed: 0.7 to 1.3 kt. Ebb tidal surface currents cause sea surface transport to be directed toward the northeast (average maximum speed: 0.7 to 1.2 kt) (NLMOC 2000).

Average wave height in the Vieques Passage (body of water between NAPR and Isla de Vieques [Vieques]) ranges from 3 to 5 ft (0.9 to 1.5 m) (NLMOC 2000). Roughest seas are from January through March when 10 to 20% of waves are greater then 8 ft (2.4 m) in height. During the rest of the year, 10% of waves are greater than 8 ft (2.4 m) in height (NLMOC 2000).

Seawater temperature is coolest from December through February (78 to 80°F, 25.5 to 26.7°C) and warmest from June to September (82 to 84°F, 27.8 to 28.9°C) (NLMOC 2000).

4.0 ESSENTIAL FISH HABITAT

MSFCMA (PL 94-265, as amended through October 11, 1996) states “EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Further, the MSFCMA identifies ‘‘waters’’ as including aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; ‘‘substrate’’ as including sediment, hard bottom, structures underlying the waters, and associated biological communities; ‘‘necessary’’ as meaning the habitat required to support a sustainable fishery and the contribution of the managed species to a healthy ecosystem; and ‘‘spawning, breeding, feeding, or growth to maturity’’ to signify a full life cycle of a species. The MSFCMA defines fish to include finfish, mollusks, crustaceans, and all other forms of marine and plant life other than marine mammals and birds.

In the Caribbean, EFH is identified and described based on areas where various life phases of 17 selected managed species (15 fishes, one crustacean, and one mollusk) and the coral complex commonly occur. The selected species are: Nassau grouper, red hind, coney, yellowtail snapper, mutton snapper, schoolmaster, gray snapper, silk snapper, banded butterflyfish, squirrelfish, white grunt, queen triggerfish, sand tilefish, redtail parrotfish, scrawled cowfish, spiny lobster, and queen conch. The selected species represent some of the key species under management by the council. Collectively, these species commonly occur throughout all the marine and estuarine waters of the U.S. Caribbean. The council believes that the EFH for these species fairly represent the EFH for the remaining species in the management unit (CFMC 1998a).

The CFMC has defined EFH as everywhere that the managed and selected species commonly occur. Because these species collectively occur in all habitats of the U.S. Caribbean, the EFH includes all maritime waters and substrates (mud, sand, shell, rock, and associated biological communities), including coral habitats (coral reefs, coral hardbottoms, and octocoral reefs), sub-tidal vegetation (seagrasses and algae), and adjacent intertidal vegetation (wetlands and mangroves). Therefore, EFH includes virtually all marine waters and substrates from the shoreline to the seaward limit of the Exclusive Economic Zone (EEZ) of the U.S. The EEZ of Puerto Rico and its islands includes all waters to the boundaries of Venezuela to the south, Dominican Republic to the west, and the British Virgin Islands to the east. The Commonwealth of Puerto Rico has jurisdiction over the territorial waters from shore to the 9 nautical mile (NM) boundary.

4.1 CARIBBEAN MARINE HABITAT AREAS OF PARTICULAR CONCERN

Habitat areas of particular concern (HAPC) are defined in the MSFCMA as those portions of EFH that are essential to the life cycle of important species. The CFMC has identified three generic habitat types in Puerto Rico as HAPCs: estuaries, near shore reefs, and hard-bottom areas. Estuaries are important to many fishery species, particularly as nursery grounds. Nearshore reefs and other hard-bottom areas are also considered as HAPCs because of their fishery value (CFMC 1998a). No other HAPCs are identified for Puerto Rico waters.

4.2 CARIBBEAN FISHERY MANAGEMENT PLANS AND SPECIES OF CONCERN

NMFS regulations for designating EFH call for detailed information on the species and habitats to be used for designating EFH (e.g., the relationship between species and their habitat during each of the species life stages – eggs, larvae, juveniles, adults, and spawning adults). However, the CFMC determined that it does not have sufficient information to identify EFH for each species in its FMPs. Therefore, the CFMC's approach has been to identify the general trophic and biological characteristics of species for each FMP, and in the absence of specific life history/habitat information, to use certain selected species as EFH "indicators" (CFMC 1998a).

4.2.1 Reef Fish Fisheries Management Plan

The Reef Fish FMP includes 139 species in 37 families (CFMC 1998b). Because of time constraints and limited availability of data, 15 fish species were selected by the CFMC as representatives of high priority reef habitats.

According to the CFMC (1998a), the habitats used by the various life stages of reef fish include mangroves, seagrass beds, non-vegetated bottoms (such as sand and mud), algal plains, and coral reefs (including solitary corals, patch reefs, and emerging reefs). A Puerto Rico marine habitat for which there is very little fisheries-specific information is hard bottom, which is the single most common bottom type in the U.S. Caribbean. There is no overall description of hard bottoms and no map of their distribution for Puerto Rico. All of the CFMC-selected species, except for the sand tilefish, have been reported over hard bottom.

All of the 15 selected species have planktonic eggs and larvae, the distribution of which is unknown. Except for general descriptions, there is little information on the distribution of eggs and the development of larvae, and almost none on the settling of fish larvae and subsequent development for U.S. Caribbean species. Juvenile development, habitat, and feeding characteristics are generally not described for the selected species. Specific EFH for the adult stages of the selected reef species is not yet identified in the FMP. Except for the red hind, adult spawning areas for the selected species have not been specifically identified in Puerto Rico waters (CFMC 1998a). The only specific EFH habitats that the CFMC actively manages in Puerto Rico waters are those associated with red hind. The CFMC Reef Fish FMP specifies three Puerto Rico EFH areas as red hind spawning aggregation areas located off the west coast of Puerto Rico.

4.2.2 Spiny Lobster Fisheries Management Plan

The Spiny Lobster FMP includes three species of lobster, but only the spiny lobster is under regulation. The Spiny Lobster FMP indicates that EFH identification for the spiny lobster in Puerto Rico waters is a work in progress and that there is no quantitative information available to determine the condition of habitats used by spiny lobster. Generally, adults mate at the edge of the island shelf. Fertilized spiny lobster eggs, which are attached to the swimmerets of the female lobster, hatch in approximately four weeks. The larval stage of spiny lobster is up to six months and includes numerous planktonic larval stages (phyllosoma). The distribution of spiny lobster larvae in the water column and their temporal and ontogenetic patterns across an inshore-offshore gradient are currently being studied (CFMC 1998a). The most important habitats for juvenile lobster appear to be turtle grass (*Thalassia testudinum*) beds and mangroves while adult populations are associated with reefs and hard bottoms, mostly with coral outcrops, crevices, caves, and ledges. Spiny lobster take is managed by regulating the gear methods for capturing the species, size limitation based on the carapace length, and the prohibition of taking of egg-bearing (“berried”) female lobsters (CFMC 1990, 1981).

4.2.3 Queen Conch Fisheries Management Plan

The Queen Conch FMP includes 13 species of conch, of which only the queen conch is under management. The Queen Conch FMP documents life history stage information and EFH for the queen conch, but only for a limited area around La Parguera in the southwest corner of Puerto Rico. There is no quantitative information available to the CMFC to determine the condition of habitats used by the queen conch (CFMC 1998a). Demersal egg masses are spawned in clean coral sand and have been found in seagrass beds. The female conch covers the egg masses with sand grains for an incubation period of approximately five days. Queen conch larvae (veligers) are pelagic for approximately three weeks before settling. The Queen Conch FMP states, “Substrate conditions to metamorphose and settle to the bottom seem critical but unfortunately at the present the requirements are largely unknown.” Required habitat for juvenile conch, which requires red algae for feeding, includes a balance between seagrass beds and surrounding sandy areas (CFMC 1998a). Adult queen conch commonly occur on sandy bottoms that support the growth of seagrasses, primarily turtle grass, manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii),* and epiphytic algae upon which they feed (Randall 1967). They also occur on gravel, coral rubble, smooth hard coral, or beach rock bottoms, and sandy algal beds. The queen conch fishery is managed by regulating the size limit, fishing gear type, quota and bag limits, and seasonal closure for taking of the species (CFMC 1996).

4.2.4 Coral Fisheries Management Plan

The Coral FMP includes more than 100 species of corals (including stony corals, sea fans, and gorgonians) and more than 60 species of plants (including seagrasses) and invertebrates (CFMC 1998b). The FMP establishes regulations to restrict the taking of coral reef resources from within the EEZ.

Although corals are present around much of Puerto Rico, physical conditions result in only localized reef formation. On the northwest and north coasts of Puerto Rico (between Aguadilla and Carolina), reef development is almost non-existent. This probably results from one or more of the following factors: high rainfall, high fresh water run-off of silt-laden river waters, intense wave action, and long-shore currents moving material westward along the coast. Reefs along the north coast of Puerto Rico are described as being only scattered and characterized by poorly developed coral growth (CFMC 1998a).

Corals produce sexually and asexually. Sexual reproduction results in the formation of minute larvae (planulae) that spend a variable amount of time in the water column as plankton (from days to weeks), eventually settle on an appropriate substrate. If reproduction is asexual, larvae are generally brooded in the gastric pouch of the parent and released when ready to settle (CFMC 1998a). Factors that influence the settlement of sessile organisms include total surface area available for settlement, conditioning period of substrate, surface relief including crevices and ridges, substrate orientation, and substrate composition (Wheaton 1989). There is little information regarding juvenile coral species. The EFH for adult corals is defined on the basis of bottom types, as this is where they grow to maturity, breed, and spawn (CFMC 1998a). The CMFC states, “There is an urgent need to conduct comprehensive quantitative surveys of seagrass and reef habitats throughout the insular platform area of Puerto Rico and the U.S. Virgin Islands. Without such information, it is not possible to adequately document the extent of these habitats, to identify those that may be particularly critical to various life phases of significant commercial and recreational species, or to best locate marine reserves” (CFMC 1998a).

The coral fishery is managed by restricting the taking of coral reef resources from the EEZ around Puerto Rico (CFMC 1994, 1999). The Coral FMP prohibits the harvest or possession of stony corals, sea fans, gorgonians, and any other species that is attached to or existing upon live rock.

4.3 CHARACTERIZATION OF ESSENTIAL FISH HABITAT

4.3.1 Mangroves

Mangroves at NAPR have been assessed since 1936 with an emphasis on Los Machos Mangroves, the largest mangrove forest on the Puerto Rico eastern coastline between Punta Mata Redonda and Punta Patillas (Weaver 1976; Lewis 1986; DON 1996). In 1999, GMI conducted the jurisdictional delineation of mangroves of NAPR and found that a total mangrove cover of 3,055 ac (1,237 ha) (DON unpublished data) (**Figure 3**). Recent surveys of mangroves at NAPR include (1) the GMI assessment of the Los Machos Mangroves at 103 random sampling points conducted in 2002 (DON unpublished data); (2) an assessment of the northernmost point of Ensenada Honda (shoreline to the airfield runway and along Towway Road, and a control site near the western edge of NAPR) (Lehman et al. 2001; DON 2002a); and (3) a habitat characterization of three Solid Waste Management Units (SWMU) 1, 2 and 45 on NAPR (Wilkinson et al. 2000).

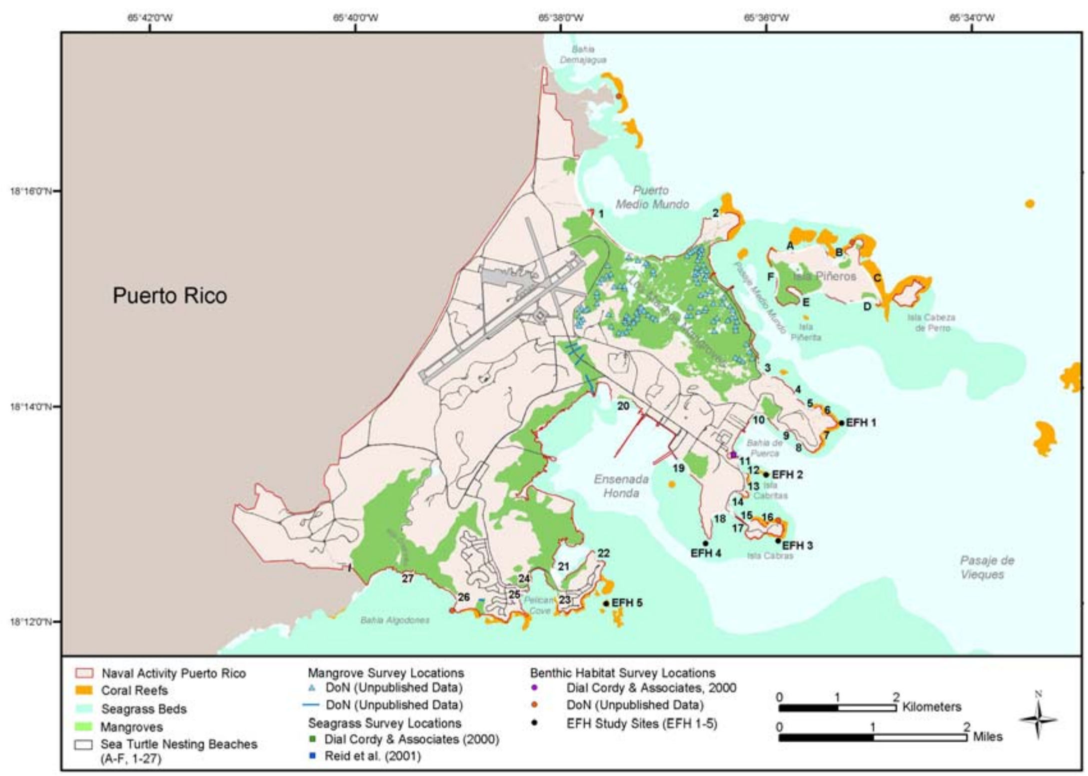

Figure 3. Distribution of Coral Reefs, Seagrass Beds and Mangrove Forests at NAPR (NOAA/NOS 2001; DON unpublished data) and Survey Locations of Mangrove, Seagrass, and Benthic Habitat Studies (DON unpublished data; Reid et al. 2001; **Appendix A**)

Mangroves on NAPR mainly consist of red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*) (DON 1996; Wilkinson et al. 2000; DON 2002a). There are also small amounts of the buttonwood mangrove (*Conocarpus erectus*). A survey of mangroves along the margin of Ensenada Honda also found the following species within the mangrove community: leather ferns (*Achrosticum aureum*), cattails (*Typha domingensis*), Puerto Rican royal palm (*Roystonea borinquena*), and portia-tree (*Thespesia populnea*) (DON 2002a).

Red mangroves are found in the fringe, riverine, and dwarf mangrove communities (DON 1996). They tolerate relatively deep water levels; grow in unstable, soft soil; and tolerate a salinity range of 10 to 55 parts per thousand (ppt). Red mangroves develop large prop roots which usually extend above the water surface. Black mangroves generally grow in areas that are not inundated by water. Black and white mangroves are much more salt tolerant than red mangroves and can exist in stagnant water.

Mangroves on NAPR provide habitat for wildlife, fish, and benthic organisms. They are also natural filters for upland runoff and protect the coastline from storm damage (Lewis 1986). In 1986, Lewis reported 112 species of birds (including the endangered yellow-shouldered blackbird, *Agelaius xanthomus*) that use the NAPR mangroves as habitat for feeding, nesting, and roosting. The mangrove prop root habitat in Puerto Rico is used by at least 13 species of fish (including *Lutjanus griseus*, *L. synagris*, *Holocanthus tricolor*), several crustaceans (including *Crassotera rhizophorae* and *Isognomon alatus*), gastropods (including *Melampus coffeus* and *Littorina angulifera*), echinoids (*Diadema antillarum*, *Eucidaris tribuloides*), sponges (*Tedania ignis*), ascidians (*Acsidia nigra*) and hyroids (*Halocordyle disticha*) (DRNA 1995).

4.3.2 Seagrasses

Seagrasses provide habitat for sea turtles, fishes, waterfowl, manatees, crustaceans, and shellfish. (Coles et al. 2001). Seagrasses of Puerto Rico consist of seven species: turtle grass (*Thalassia testudinum*), sea vines (*Halophila decipiens*), *Halophila baillonis*, *Halopohila engelmannii*, manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*) (Vicente 1992). The most common of these are *T. testudinum*, *H. decipiens*, *S. filiforme*, and *H. wrightii*. *H. engelmannii* is restricted to few locations of Puerto Rico (north and southeast coastline). *R. maritima* is only found in enclosed lagoons with limited oceanic influence (Vicente 1992). The shallow and protected NAPR coastline is favorable to the presence of relatively extensive areas of seagrass cover (Vicente 1992; NOAA/NOS 2001) (**Figure 3**). The region offshore NAPR extending to Vieques is characterized by expansive flat shallow areas dominated by turtle grass and manatee grass (Vicente 1992; Reid et al. 2001). The depth limit of seagrass distribution is determined by factors including substrate type, turbidity, insolation, and grazing pressure (Vicente 1992).

Seagrasses along the NAPR coastline were surveyed in 2000 off the proposed LRA's Reuse Plan zones 7A and 7B (Bahia Puerca; former NSRR Landfill; Dial Cordy 2000a) and off zone 9 in Ensenada Honda (Dial Cordy and Associates 2000b) (**Figure 3**). Reid et al. (2001) documented three seagrass beds along NAPR: two areas off zone 9 (Bundy Cove and Ensenada Honda), and one area off zone 7B (Ensenada Honda) (**Figure 3**). In 2003, benthic communities that included seagrasses were characterized at four study sites within 164 ft (50 m) of the NAPR shoreline at Punta Figueras, Isla Piñeros, Isla Cabras, and Daguao (DON unpublished data).

The sand shelf (less than 10 ft (3 m) water depth) off the former NSRR Landfill in Bahia Puerca supported *T. testudinum*, and *S. filiforme* (Dial Cordy and Associates 2000a). The *T. testudinum* cover ranged from 50 to more than 75% in the shallow subtidal area. Seagrasses were not found in waters deeper than 10 to 15 ft (3 to 4.5 m) off the former NSRR Landfill. At the northern end of Ensenada Honda, Dial Cordy and Associates (2000b) found mostly *T. testudinum* (> 80% of the samples), and *H. wrightii*, *S. filiforme*, and *H. decipiens*. The cover of *T. testudinum* at the northern end of Ensenada Honda ranged from 5 to more than 75% (Dial Cordy and Associates 2000b). Seagrass beds surveyed in 1999 by Reid et al (2001) within Ensenada Honda and in Bundy Cove all consisted of mostly *T. testudinum* (> 75% cover). The site at the northern end of Ensenada Honda was only composed of *T. testudinum*. The other two sites did contain some *S. filiforme* (less than 5% to more than 25%) (Reid et al. 2001).

In 2003, seagrasses found in a nearshore site off the Punta Figueras shoreline consisted of *T. testudinum* (6% cover) (DON unpublished data). On the northern and exposed shoreline of Isla Piñeros, there was sparse seagrass cover consisting of *T. testudinum* (< 1%) and *S. filiforme* (4% cover). A nearshore site at Cabras Island contained *T. testudinum* (8% cover) and *S. filiforme* (< 1% cover). A site 0.6 mi (0.9 km) west of Punta Algodones contained *T. testudinum* (15% cover) *and S. filiforme* (10% cover) (DON unpublished data).

4.3.3 Coral Reefs

Species of corals found in shallow water around the eastern end of Puerto Rico are typical of those found elsewhere in the Caribbean (Almy et al. 1963; Humann 1993). Common species include boulder star coral (*Montastraea annularis* species complex), finger coral (*Porites porites*), and elkhorn coral (*Acropora palmata*). Extensive reefs popular with sport divers exist both to the north (off Fajardo) and south (off Humacao) of NAPR (Simonsen 2000). Along the NAPR shoreline, coral formations tend to be very close to shore (i.e., often less than 328 ft (100 m) from shore).

As with the corals, the assemblage of reef fishes found around Puerto Rico are representative of the generalized Caribbean fauna (Humann 1994; Hernandez-Delgado et al. 2000). Shallow reefs around Puerto Rico have ichthyofaunas dominated by wrasses (family Labridae) and damselfishes (family Pomacentridae) (Garcia and Castro 1999).

Two recent benthic surveys conducted along the NAPR shoreline characterized corals at nine sites: Punta Figueras, Isla Piñeros, Punta Puerca (EFH 1), Isla Cabritas (EFH 2), Isla Cabras (north), Isla Cabras (south, EFH 3), the end of the Ensenada Honda northern peninsula (EFH 4), off the end of the Ensenada Honda southern peninsula (EFH 5), and a site 0.6 mi (0.9 km) west of Punta Algodones (DON unpublished data; **Appendix A**) (**Figure 3**). The depth range of these sites was 7 to 23 ft (2 to 7 m). Summaries of results from these studies are presented in **Tables 1** and **2** and **Figures 4** and **5**. Benthic cover data in Department of the Navy (DON) (unpublished data) and **Appendix A** are the result of six 33 ft (10 m) long linear point intercept (LPI) transects conducted at each site, except for the Daguao site where only two LPI transects were done.

Coral cover, as surveyed within the nine sites along NAPR, is characteristically less than 15% (**Tables 1** and **2**). Most of the benthic cover at these sites consisted of turf algae (cover range: 19 to 53%) and macroalgae (cover range: 9 to 51%) (**Figures 4** and **5**). Mean coral cover on shallow reefs 3 to 16 ft (1 to 5 m) of Puerto Rico is estimated at 16% and mean algal cover is estimated at 65% (Garcia et al. 2004).

There were at least 13 species of corals that composed the coral cover observed along NAPR (DON unpublished data; **Appendix A**). Most common coral taxa among sites observed on the LPI transects were *Diploria strigosa*, *Porites astreoides*, and *Siderastrea siderea* (**Table 3**). The most abundant coral taxon observed under the LPI transects was *P. astreoides*. Sites with the most coral diversity based on the LPI data were EFH 3 and EFH 4 with eight and ten coral taxa, respectively. Except for sites EFH 3, Punta Figueras, Isla Cabras (north), and Daguao, gorgonian cover was higher than coral cover at sites surveyed in 2004 (cover range: 8 to 25%) (**Tables 1** and **2**). Characteristics of these NAPR sites are similar to the average shallow coral reef site described by Garcia et al. (2004).

The long-spined urchin, *Diadema antillarum*, was observed under the LPI at three of the nine sites (Daguao, EFH 3, and EFH 4). Belt transects conducted in 2004 showed that there were on average 0 to 0.02 *D. antillarum* per square foot (ft^{-2}) (0 to 0.24 per square meter (m^{-2}) and 0 to 0.01 *Echinometra* spp. ft^{-2} (0 to 0.14 m^{-2}). While *D. antillarum* is not completely absent at the study sites, densities remain very low compared with areas where it is making a come back (~5 individuals m^{-2} in northern Jamaica; Edmunds and Carpenter 2001).

Coral reefs in Puerto Rico including the vicinity of NAPR are potentially exposed to the following sources of human-induced threats that compound natural changes on reefs (including hurricane impacts): overfishing, polluted runoff (including sewage, pesticides), coastal development, upland deforestation,

Table 1. Mean Percent Cover of Benthic Taxa and Substrates at Four Nearshore Sites along NAPR As Recorded in 2003 along Replicate 33 ft (10 m) Long Line Point Intercept Transects (DON unpublished data). (PF: Punta Figueras; IP: Isla Piñeros; IC: Isla Cabras (north); D: Daguao)

Taxon/Substrate	PF	IP	IC	D
Turf Algae	25.0	19.0	32.8	47.5
Macroalgae	36.7	50.5	33.2	25.0
Seagrass	11.2	4.0	22.0	0
Sponge	0	1.8	1.3	5.8
Coral	7.3	3.5	3.2	13.9
Gorgonian	0.8	14.5	3.0	3.0
Zoanthid	13.7	0.2	0.2	1.8
Diadema antillarum	0	0	0	0.3
Echinometra spp.	0.7	0	0	0
Sand	2.0	6.5	3.8	2.0
Rock	0.5	0	0	1.4
Dead Coral	0	0	0.2	2.0

Table 2. Mean Percent Cover of Benthic Taxa and Substrates at Five Nearshore Sites along NAPR as Recorded in 2004 along Replicate 33 ft (10 m) Long Line Point Intercept Transects (**Appendix A**).

Taxon/Substrate	EFH 1	EFH 2	EFH 3	EFH 4	EFH 5
Turf Algae	28.0	32.3	40.3	52.7	53.0
Crustose Algae	0.0	0.0	0.3	0.0	0.0
Macroalgae	9.0	35.7	19.7	24.0	27.3
Seagrass	0.0	0.0	17.3	0.3	0.0
Sponge	20.3	1.7	0.3	2.0	1.7
Coral	4.3	4.0	10.3	6.7	4.0
Gorgonian	24.7	10.7	5.7	11.7	8.3
Zoanthid	4.7	0.0	0.0	0.0	0.3
Diadema antillarum	0.0	0.0	0.3	0.3	0.0
Sand	9.0	15.7	5.7	2.3	5.3

Table 3. Coral Taxa Composing the Coral Cover at Nine Nearshore Sites along NAPR as Recorded under Replicate 33 ft (10 m) Long Line Intercept Transects in 2003 and 2004 (DON unpublished data; **Appendix A**) (PF: Punta Figueras; IP: Isla Piñeros; IC: Isla Culebra (north); D: Daguao).

Coral taxa	PF	IP	EFH1	EFH2	IC	EFH3	EFH4	EFH5	D
Agaricia spp.	-	X	-	-	-	X	X	x	-
Diploria clivosa	X	-	-	-	X	-	X	-	X
Diploria labyrinthiformis	-	-	-	-	X	-	-	-	-
Diploria strigosa	X	X	X	-	X	X	X	-	-
Millepora spp.	-	-	X	X	-	X	X	-	X
Montrastraea cavernosa	-	X	X	-	-	X	X	-	X
Montastraea faveolata	-	-	-	X	-	X	X	-	-
Montastraea faveolata?	-	X	-	-	-	-	-	-	-
Montastraea franksi	-	-	X	-	-	-	X	-	-
Porites astreoides	X	-	X	X	X	X	X	X	X
Porites porites	-	X	-	-	-	X	-	-	-
Siderastrea radians	-	X	-	-	x	-	X	-	X
Siderastrea siderea	-	-	X	X	X	X	X	X	-
Stephanocoenia michelini	-	-	-	-	-	-	-	-	X
Total	3	6	6	4	6	8	10	3	6

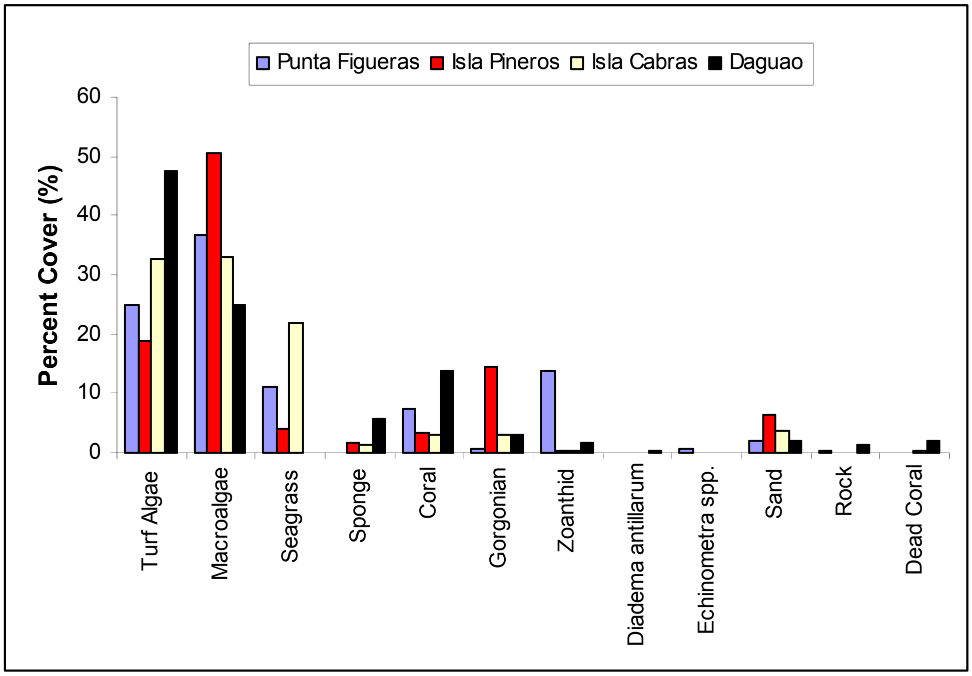

Figure 4. Composition of the Benthos (Taxa and Substrates) at Four Nearshore Sites along NAPR as Recorded in 2003 along Replicate 33 ft (10 m) Long Line Point Intercept Transects (DON unpublished data).

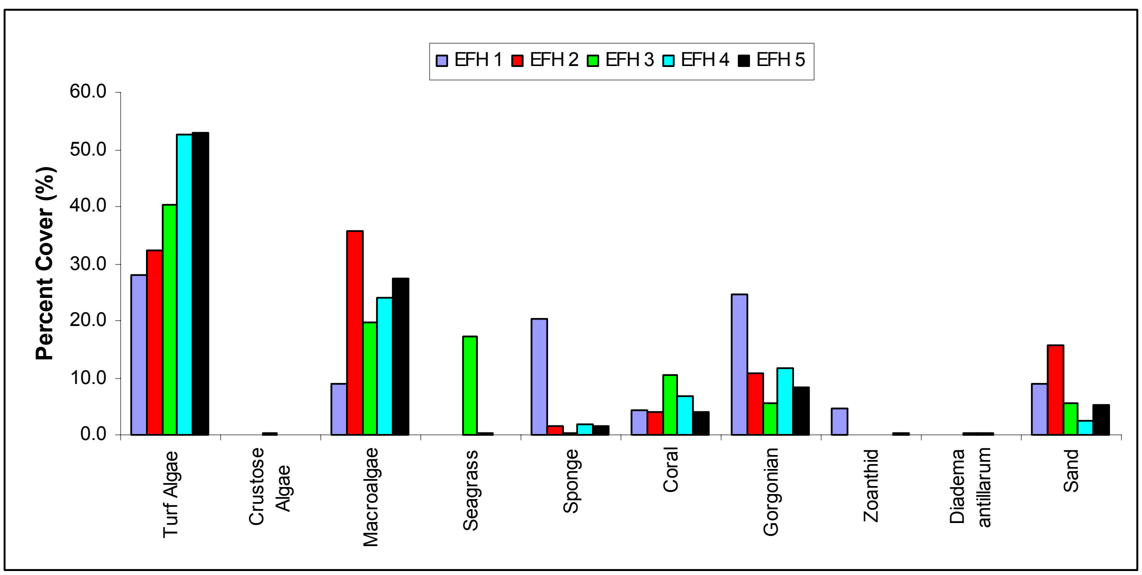

Figure 5. Composition of the Benthos (Taxa and Substrates) at Five Nearshore Sites along NAPR as Recorded in 2004 along Replicate 33 ft (10 m) Long Line Point Intercept Transects (**Appendix A**).

anchoring, and destructive fishing techniques (Sullivan-Sealy and Bustamante 1999; Causey et al. 2000; Garcia et al. 2004). These sources of impact can or already have led to the serious deterioration of coral reef habitat and structure in reefs of Puerto Rico and the Virgin Islands as a result of nutrification, sedimentation, and mechanical damages to corals (Sullivan-Sealy and Bustamante 1999; Causey et al.

2002; Garcia et al. 2004). Upland deforestation and the resulting sedimentation on fringing reefs (closest to shore) are thought to be the most significant threat to coral reefs in Puerto Rico (CFMC 2004).
The CFMC established a FMP to restrict the taking of coral reef resources within Puerto Rico and the U.S. Virgin Island's Exclusive Economic Zone (EEZ). The Coral FMP regulates the harvest, possession, or sale of stony corals, sea fans, gorgonians, and other species attached to live-rock as well as the use of chemicals, toxins, or explosives to harvest any species (CFMC 2004). More than 100 species of coral and over 60 species of algae, seagrasses, and invertebrates are protected by the Coral FMP (CFMC 2004). The nearshore reefs and hard bottom areas adjacent to Puerto Rico and the USVI are designated as HAPC because of their fishery value.

Human-induced stressors that impact the north and south coastal environments of Puerto Rico include water quality changes (increased terrigenous sediment input and increased nutrient/sewage input), coastal habitat loss caused by development, uncontrolled recreational activities, and the decline in species abundance (from overfishing) (Hernández-Delgado and Sabat 1998; Sullivan-Sealey and Bustamante 1999; Causey et al. 2002; Morelock et al. 2001).

The main naturally induced impacts on coral reefs are caused by hurricanes, storm damage, silt-laden runoff following heavy rainfall/floods, the Caribbean-wide morality of the long-spined urchin in the 1980s, repeated coral bleaching events of the 1980s, and widespread coral diseases (Glynn et al. 1964; Goenaga and Canals 1990; Bruckner and Bruckner 1997; Causey et al. 2002; Morelock et al. 2001; Gardner et al. 2003). The additive pressures of naturally occurring and anthropogenic stresses have led to the critical status of Puerto Rican coral reefs (100% at risk; Spalding et al. 2001).

5.0 EFFECTS OF THE PROPOSED ACTION

EFH consultation is the process of satisfying the federal agency consultation and response requirements of section 305(b)(2) and 305(b)(4)(B) of the MSFCMA, and the EFH Conservation Recommendation requirement of section 305(b)(4)(A) of the MSFCMA. Under section 305(b)(2) of the MSFCMA, each federal agency shall consult with respect to any proposed action that "may adversely affect" any EFH. Adverse effect means "any impact which reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH (50 CFR 600.910). This is a definition that includes direct, indirect and cumulative effects.

Waterfront as well as inland reuse and development activities may affect EFH as point or non-point sources of impacts both in the short- and long-term (**Figures 1** and **6**). A fundamental component to help minimize and prevent short- and long-term impacts associated with the proposed follow-on action (LRA's Reuse Plan) will be the effectual communication and application of EFH conservation recommendations. A solution-oriented communication between federal and local regulating agencies, the Local Redevelopment Authority and the Department of Economic Development and Commerce (Commonwealth of Puerto Rico), the construction contractors, and facility users will be paramount to the long-term preservation of managed and associated species, as well as EFH in areas potentially impacted by the proposed reuse and development plan.

5.1 EFFECTS ON MANAGED AND ASSOCIATED SPECIES

Sites surveyed for reef fishes and benthic organisms at nine sites along the NAPR coastline contained seven CFMC-managed reef species, the spiny lobster, and 13 reef coral species (**Tables 4** and **5**) (DON unpublished data; **Appendix A**). Overall 65 species of fish were observed among the nine sites. Fish abundance was relatively low, and so were the abundances of CFMC-managed fish species (**Appendix A**). Reef fishes of the NAPR waterfront may loose suitable coral reef habitat as a result of the proposed follow-on action identified by the LRA's Reuse Plan should the reefs further deteriorate as a result of increased sedimentation and turbidity, nutrient loading, and coral mortality. Increased fishing pressure on reefs along NAPR resulting from recreational fishing associated with the LRA's Reuse Plan may cause fish diversity and abundance to become further depleted.

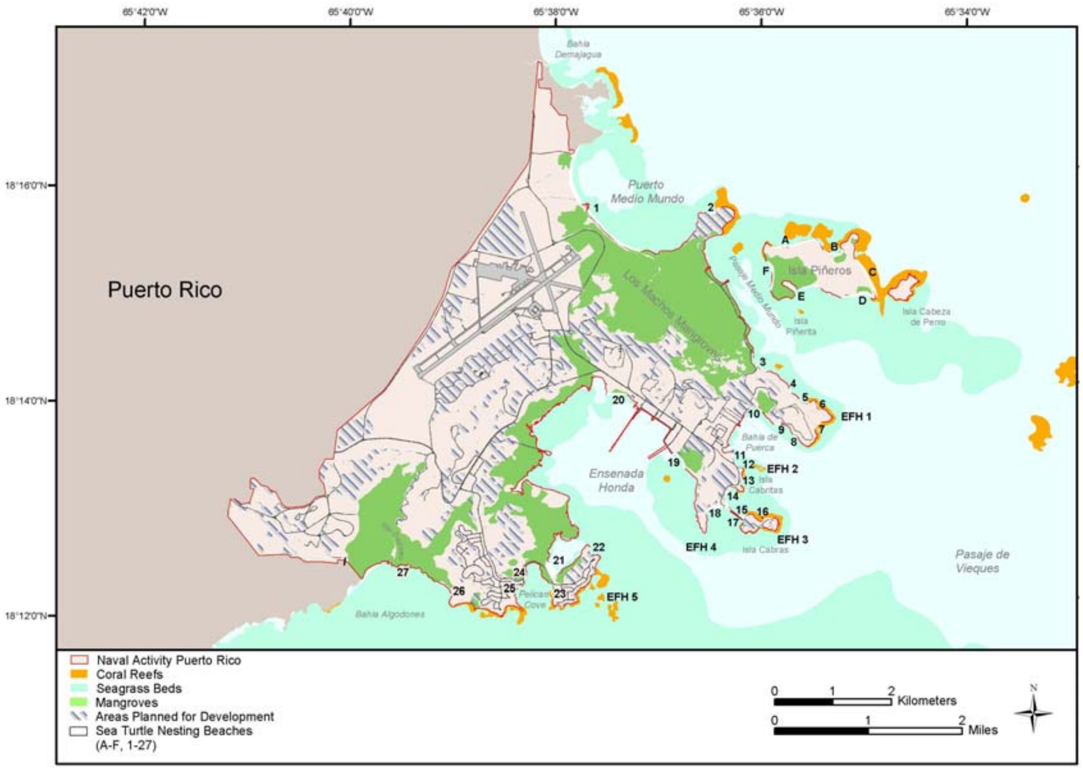

Figure 6. Distribution of Coral Reefs, Seagrass Beds and Mangrove Forests at NAPR (NOAA/NOS 2001; DON unpublished data) and Areas Planned for Development under the LRA Reuse Plan (CBRE 2004)

Table 4. Managed and Associated Species (CFMC 2004) Found within NAPR Based on Fish Censuses and Benthic Belt Transects Conducted in 2003 (DON unpublished data).

FMP	Common Name	Scientific Name	PF	IP	IC	D
Reef fish	Squirrelfish	*Holocentrus adscensionis*	X	X	X	-
	Red hind	*Epinephelus guttatus*	-	X	-	-
	Schoolmaster	*Lutjanus apodus*	X	X	-	-
	Yellowtail snapper	*Ocyurus chrysurus*	X	-	-	-
	Banded butterflyfish	*Chaetodon striatus*	X	-	-	-
	White grunt	*Haemulon plumieri*	-	-	-	-
	Redtail parrotfish	*Sparisoma chrysopterum*	-	-	-	-
	Scrawled cowfish	*Acanthostracion quadricornis*	-	-	-	-
Spiny lobster	Spiny lobster	*Panulirus argus*	-	-	-	-
Queen conch	Queen conch	*Strombus gigas*	-	-	-	-
Coral and coral reefs	Coral and coral reefs	All corals	X	X	X	X

5.2 EFFECTS ON HABITAT

5.2.1 Mangrove

The proposed reuse and development plan should cause no impact on mangrove forests of NAPR considering the plan to conserve these resources (zone 9) which should prevent any reuse and development-related impacts (CBRE 2004).

Table 5. Managed and Associated Species (CFMC 2004) Found within NAPR Based on Fish Censuses and Benthic Belt Transects Conducted in 2004 (**Appendix A**).

FMP	Common Name	Scientific Name	EFH1	EFH2	EFH3	EFH4	EFH5
Reef fish	Squirrelfish	*Holocentrus adscensionis*	-	X	X	X	X
	Schoolmaster	*Lutjanus apodus*	-	X	X	X	X
	Yellowtail snapper	*Ocyurus chrysurus*	-	-	X	X	-
	Banded butterflyfish	*Chaetodon striatus*	-	-	X	X	-
	White grunt	*Haemulon plumieri*	-	-	X	X	X
	Redtail parrotfish	*Sparisoma chrysopterum*	-	-	X	-	-
	Scrawled cowfish	*Acanthostracion quadricornis*	-	-	-	-	X
Spiny lobster	Spiny lobster	*Panulirus argus*	-	X	-	-	X
Queen conch	Queen conch	*Strombus gigas*	-	-	-	-	-
Coral and coral reefs	Coral and coral reefs	All corals	X	X	X	X	X

5.2.2 Seagrass Beds and Coral Reefs

5.2.2.1 Potential Impacts on Seagrasses and Coral Reefs

Proposed activities that may have adverse short-term and long-term effects on EFH are those that will alter coastal water quality, increase terrestrial runoff, cause excessive sedimentation, cause nutrient enrichment, and cause physical impacts on seagrasses and coral reefs (Rogers 1990; McCook 1999; Szmant 2002; Nugues and Roberts 2003; Thrush et al. 2004; Fabricius 2004). These activities may include:

- The reuse of the newly re-bulkheaded water front at the northeastern portion of Ensenada Honda as a passenger and light cargo ferry facility (zone 6, “port”)
- The water-oriented commercial development along the NAPR waterfront (including marinas, boat repair, refueling, and boat building) (zone 6, “port”)
- Residential development (zone 5, “residential”)
- Development of the Science Park (zone 7)
- Recreation activities (expansion/improvement of the existing Morale, Welfare, and Recreation marina, expansion of the golf course, ecotourism)
- Improvement and construction of roads throughout the property (in particular zone 7, “science park”)

Of the above-listed proposed activities, the residential development, the development of the Science Park, and the improvement/expansion of roads have the potential to alter nearshore water quality, and generate increased terrestrial runoff and nearshore sedimentation that could affect EFH (seagrasses and coral reefs).

The construction of buildings and roads could unavoidably produce loose sediments that could make their way into local coastal waters via the local watershed and storm water runoff. Excessive and chronic sediment input have the potential to adversely impact seagrasses and coral reef habitat and smother submerged aquatic vegetation (SAV) sessile coral reef organisms. This could affect the condition of seagrasses and possibly the irreversible decline of sessile coral reef organisms (including corals, gorgonians). The addition of paved areas (roads, parking lots) near the water front could accelerate and intensify freshwater runoff (storm water) into the ocean and the dispersal of loose sediments associated with runoff. Paved areas therefore have the potential to locally accentuate the effects of sedimentation on seagrasses and coral reefs.

Uncontrolled and chronic use of pesticides, herbicides, and fertilizers on developed lands (including residential and recreational areas) has the potential to alter the quality of the local freshwater runoff and predictably increase the exposure of seagrasses and coral reef-associated organisms to harmful chemicals (Fabricius 2004).

The ship traffic associated with the passenger and cargo ferry facility has the potential to alter water quality by the resuspension of sediments and the accidental release of fuel. Any physical impact the ferry or cargo vessels might have with seagrass-populated seafloor could cause lasting damages to seagrasses. Further, depending on the water depth at the docking site and the local cover of seagrass, the propeller wash of passenger ferry and cargo vessels may physically damage the seafloor by damaging seagrass (including blades and roots), removing seagrass, and displacing sediments (producing blow holes).

Recreational activities including boating and ecotourism have the potential to cause physical damage to seagrass and coral reef resources through accidental and/or deliberate physical contact (including boat groundings, propeller scars, anchor damage, and souvenir collection).

5.3 CUMULATIVE EFFECTS

Cumulative effects resulting from the proposed LRA's Reuse Plan should be considered against an environmental baseline that includes past and present impacts of all state, federal, and private activities in the NAPR area. While mangroves will probably incur limited impacts from the proposed follow-on action as defined in the LRA's Reuse Plan, seagrasses and coral reefs are more likely to be impacted for a number of reasons including their proximity to the proposed waterfront development and use, their chronic exposure to polluted runoff and discharges, and their chronic exposure to mechanically-induced impacts.

Seagrasses along NAPR appear to be in good condition (Reid et al. 2001). They currently cover a relatively large area (NOAA/NOS 2001) (**Figure 6**). In contrast, the occurrence of coral reefs along NAPR is somewhat limited to a narrow, nearshore area (**Figure 6**). Further, the reefs along NAPR were in poor condition as characterized by low coral cover, low coral diversity, high turf algae cover, high macroalgae cover, abundant occurrence of diseased and moribund sea fans (*Gorgonia ventalin*a), abundant coral mortality (skeletons of *A. palmata* and *M. faveolata*, and *M. annularis*), a very limited fish population, and the presence of very few echinoids. Further, during the 2004 survey of benthic communities along NAPR it became apparent that the reefs have been exposed to both the local and the regional runoff and associated sedimentation and turbidity. Heavy rainfall that occurred during the 2004 survey combined with strong winds out of the northeast allowed for the observation of local dispersion of sediment-laden runoff, the advection of turbid water from river and storm runoff from areas north of NAPR (Bahia Demajagua), and the tidal effects on the local transport of turbid waters. It appeared that naturally occurring disturbances on the reefs (including runoff and exposure) were exacerbated by the dispersion of newly-generated sediments and the resuspension of existing sediments on the seafloor. Therefore, the existing reefs along NAPR are currently under stress from existing naturally-occurring and human-induced disturbances.

Measurable impacts on EFH (seagrass beds and coral reefs) from past, current, and future activities at or near the proposed reuse and development sites at NAPR could result from incremental or synergistic disturbances including coastal construction, ship traffic (prop wash, hydrocarbon spills, ballast and waste disposal), increased use by humans (harvesting, trampling, improper trash disposal), polluted runoff (hydrocarbons, industrial and domestic waste, other chemical or solid pollutants), improper disposal of chemical and solid pollutants, mechanical impacts (anchoring, propeller plowing/scaring, ship grounding), excessive fishing, recreational boating, tourism, as well as natural disturbances including excessive sedimentation and turbidity following storms and hurricanes (CFMC 1998a; Sullivan-Sealy and Bustamante 1999). Negative impacts on seagrass beds and coral reefs would be followed by difficult and slow recoveries.

A primary concern regarding potential impacts on seagrass beds is nutrient loading (Short et al. 2001). Should the local/regional watershed and runoff become enriched with excessive nutrients and the water bathing local seagrasses be subject to eutrophication (as caused by nitrogen loading), then severe impacts on local seagrass beds would follow. Commercial and recreational boat/ship traffic within the NAPR area could cause unavoidable water quality changes (e.g., increased turbidity, decreased dissolved oxygen, cumulative input of chemical contaminants), that may affect both seagrasses and coral reefs.

Considering the layout of the proposed development in the LRA's Reuse Plan, the areas where EFH (seagrasses and coral reefs) could be mostly impacted are probably those in Pelican Cove, the eastern coast of Ensenada Honda, and all of Bahia Puerca (**Figure 6**). The uncontrolled release of nutrient-enriched water (sewage, fertilizers) could cause adverse effects on seagrass beds and coral reefs. Sedimentation and turbidity resulting from the construction of buildings and roads, particularly in waterfront areas immediately adjacent to proposed development sites, could also be a source of impacts on seagrasses and coral reefs. Chronic and/or excessive sedimentation and turbidity could cause severe degradation of seagrass and coral reef habitat and associated resources.

The deterioration of seagrass beds would not only impact the plant community but also the organisms that use or depend on the seagrasses for habitat, food, and reproduction (breeding ground and nursery) including sea turtles, fishes, waterfowl, manatees, crustaceans, and shellfish (Coles et al. 2001). Deteriorated seagrasses would be less capable of acting as filters of nutrients and contaminants, and as natural dampeners to wave action. Deleterious water quality changes in the NAPR area could cause a shift in the species composition of the seagrass plan community (from *T. testudinum*-dominated to other seagrass or algae species), changes in abundance of seagrasses, and changes in leaf productivity (Reid et al. 2001).

Coral reefs at NAPR could be affected by increased sedimentation and turbidity and become further degraded (Gardner et al. 2003). Should this happen, the existing coral diversity would probably decrease. Corals would die as a result of being repeatedly smothered and become covered by turf algae and macroalgae. The bioerosion of dead coral substrate would result in a loss of the three-dimensionality of the habitat which would impact the limited number of coral reef-associated organisms (including fishes) that populate these reefs (Gardner et al. 2003). Remaining gorgonians would probably die off. Other changes to water quality including pulses of increased nutrient content would compound the effects of sedimentation and turbidity (Gardner et al. 2003).

Because of the long-term nature of the use and development of the NAPR area, there is a potential for synergic impacts of existing natural and human-induced disturbances on EFH (local and regional), and reasonably foreseeable uses and development of the proposed facilities at NAPR, particularly at along the eastern coastline of Ensenada Honda, Bahia Puerca, and Pelican Cove. Cumulative impacts are expected to be concentrated in waterfront areas and influence the function and productivity of local seagrasses and coral reefs (**Figure 6**).

Following is a summary of existing impacts, potential LRA's Reuse Plan-related impacts, and potential cumulative impacts on EFH (seagrasses and coral reefs) at NAPR:

- **WATERFRONT ZONES**
  - *Existing impacts*: Sedimentation and high turbidity on coral reefs bordering NAPR.
  - *Potential reuse and new development impacts*: (1) nutrient loading (domestic waste, fertilizers), (2) increased sediment-laden runoff, (3) mechanical impacts on seagrasses and coral reefs (commercial and recreational activities); (4) injury or mortality of manatees and sea turtles caused by boat/ship traffic.
  - *Potential cumulative impacts*: (1) eutrophication, (2) increased sedimentation and turbidity (local and regional sources), (3) coral morality, (4) degradation of seagrasses, (5) disruption and degradation of sea turtle nesting beaches, and (6) manatee and sea turtle injuries and mortality.

6.0 MITIGATION AND CONSERVATION MEASURES

6.1 MITIGATION

The disposal of NAPR property to federal and other future property owners would not in and of itself result in impacts to EFH, managed and associated species, and protected species. Therefore, no Navy instituted mitigation measures are proposed.

However, there are a number of mitigation measures that Commonwealth and Federal resource agencies could/may impose on future owners/developers prior to them being issues development specific approvals or permits. Any of these mitigation requirements would be the responsibility of the respective issuing agency, as the Navy would no longer retain any ownership or control of the property.

Following is a list of these potential mitigation measures that could be implemented to minimize impacts on EFH, managed and associated species, and protected species:

- Prevent nutrient loading of Pelican Cove, Ensenada Honda, and Bahia Puerca.
- Contain (prevent the dispersion of) loose sediments generated during construction.
- Develop a seagrass/mangrove/manatee/sea turtle education program (certification) for construction contractors, ferry vessel operators, and property managers.
- Monitor environmental impacts on EFH during and after the construction phase.
- Develop a long-term seagrass monitoring program for Pelican Cove, Ensenada Honda, and Bahia Puerca. The condition of seagrasses will be indicative of local water quality.
- Create a clearly marked and buoyed ferry fairway (mandatory channel) to approach the passenger ferry terminal and cargo/passenger ferry landing terminal.
- Enforce vessel speed limits and the posting of lookouts to prevent mechanical impacts on seagrass beds and collisions with manatees and sea turtles.
- Installing permanent mooring buoys at coral reefs and seagrass areas to prevent physical impacts on the seafloor caused by repeated anchoring. Establishment, maintenance, and usage of this mooring field require coordination with the Puerto Rico Department of Natural Resources for consistency with Puerto Rico's approved Coastal Management Plan.
- Prevent the improper disposal of trash during the construction phase and use of the docking facilities. Particular attention should be brought to materials made of plastic and Styrofoam, buckets, tools, liquid materials (e.g., paints, solvents, and fuels), excess construction materials, hardware, and cigarette buts.
- Provide containers for proper garbage disposal and enforce the proper disposal of garbage.
- Ensure periodic disposal of trash by garbage disposal contractors.

7.0 CONCLUSIONS

Implementation of the proposed action, the disposal of NAPR property to federal and other future property owners, would not in and of itself result in impacts to EFH, managed and associated species, and protected species.

Upon completion of the proposed action (disposal of NAPR), future land-use changes could impact EFH, managed and associated species, and protected species. Based on the information and analysis presented in the preceding sections, impacts on mangroves would probably be avoided by the proposed LRA's Reuse Plan. Under existing laws and regulations, future landowners/developers would be responsible to establish zoning, apply for building permits, and other approvals to implement their respective development projects. The engineering, design, and studies needed to obtain the various approvals from the respective regulatory agencies have not been accomplished. Should the various regulatory agencies require the mitigation discussed in Section 6, there should be minimum impacts to protected resources.

This EFH assessment, while addressing the disposal action, does not preclude the potential need for future review of specific components of the LRA's Reuse Plan pursuant to federal and Commonwealth laws. All Puerto Rican entities must comply with relevant federal laws (e.g., Clean Water Act, Clean Air Act, and to a lesser degree ESA) and Commonwealth's planning, zoning, and environmental laws.

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APPENDIX A

RAPID ECOLOGICAL ASSESSMENT (REA) OF THE NEARSHORE AREA AT NAVAL ACTIVITY PUERTO RICO

DRAFT REPORT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

$\bar{x}$	Mean
CFMC	Caribbean Fishery Management Council
cm	Centimeter(s)
DGPS	Differential Global Positioning System
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
FMP	Fishery Management Plan(s)
ft	Feet
GMI	Geo-Marine, Inc.
HAPC	Habitat Areas of Particular Concern
kt	Knot(s)
LPI	Liner Point Intercept
m	Meter(s)
m^2	Square Meter(s)
m^{-2}	Per Square Meter
MSFCMA	Magnuson-Stevens Fishery Conservation Management Act
NAPR	Naval Activity Puerto Rico
NAVFAC LANT	Naval Facilities Engineering Command Atlantic
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSRR	Naval Station Roosevelt Roads
REA	Rapid Ecological Assessment
SD	Standard Deviation
SPUE	Sighting-Per-Unit-Effort
U.S.	United States
USVI	United States Virgin Islands

1.0 INTRODUCTION

The Magnuson-Stevens Fishery Conservation Management Act (MSFCMA) (16 U.S.C. § 1801-1882) established regional fishery management councils and mandated that fishery management plans (FMPs) be developed to responsibly manage exploited fish and invertebrate species in Federal waters of the United States (U.S.). When Congress reauthorized this act in 1996, several reforms and changes were made. One change was to charge the National Marine Fisheries Service (NMFS) with designating and conserving essential fish habitat (EFH) for species managed under existing FMPs. This was intended to minimize, to the extent practicable, any adverse effects on habitat caused by fishing or non-fishing activities, and to identify other actions to encourage the conservation and enhancement of such habitat.

This rapid ecological assessment (REA) of underwater sites was prepared by Geo-Marine, Inc. (GMI) for the Naval Facilities Engineering Command Atlantic (NAVFAC LANT). The purpose of this REA is to support an EFH assessment that evaluates whether or not the proposed Naval Station Roosevelt Roads (NSRR) Reuse Plan (CBRE 2004) is likely to cause adverse effects on EFH and on species managed by the Caribbean Fishery Management Council (CFMC). The NSRR Reuse Plan proposes the reuse of existing infrastructure and facilities and the improvement/construction of new infrastructure and facilities. The proposed NSRR Reuse Plan includes:

(1) Reuse of the airport as a passenger and cargo facility
(2) Reuse of harbor facilities as a passenger and light cargo ferry facility
(3) Reuse the NSRR hospital as a civilian hospital
(4) Reuse and expansion of the NSRR 9-hole golf course
(5) Reuse of the NSRR elementary school as a public middle/high school
(6) Reuse of the NSRR middle/high school campus as a private school
(7) Reuse of NSRR academic, residential, and support facilities as a university campus
(8) Development of a science park including research and development facilities
(9) Development of industrial and commercial facilities
(10) Development of facilities supporting water-oriented commercial and recreational activities
(11) Development of residential areas
(12) Expansion of the existing marina
(13) Potential resort development

This document is part of the consultation process with the NMFS called for by the MSFCMA and its implementing rules.

Based on previous studies (DON unpublished data; Reid et al. 2001, Weaver 1976; Lewis 1986; DON 1996; Lehman et al. 2001; DON 2002; Wilkinson et al. 2000; Dial Cordy 2000a; Dial Cordy 2000b;) aerial photographs, and benthic habitat mapping (NOAA/NOS 2001), it is known that the primary habitat types in the area of interest are mangrove forests, seagrass beds, coral reefs, and turtle nesting beaches. The focus of this assessment was the coral reef habitat.

Naval Activity Puerto Rico (NAPR) (formerly NSRR) is located in Ceiba, a municipality of the Commonwealth of Puerto Rico, on the eastern end of the main island (**Figure 1**). The nearest major town is Fajardo, located 10 miles to the north of NAPR. Puerto Rico is part of the Antillean Island Arc, a chain of islands separating the Atlantic Ocean from the Caribbean Sea.

2.0 DESCRIPTION OF STUDY SITES

Study sites were identified in the NAVFAC LANT scope of work. These sites were to include coral reef habitat and be located off NSRR Reuse Plan zones 7 B-D, 5 C, 6C and 6E, and the Capehart Area (zone 5) (CBRE 2004). The map attached to the scope located five study sites on reefs/hard bottoms: Site 1 off Punta Puerca, Site 2 near Isla Cabritas, Site 3 on the south side of Isla Cabras, site 4 off of zone 6E in Ensenada Honda, and site 5 off of zone 5C, the western peninsula of Ensenada Honda. Onsite inspection

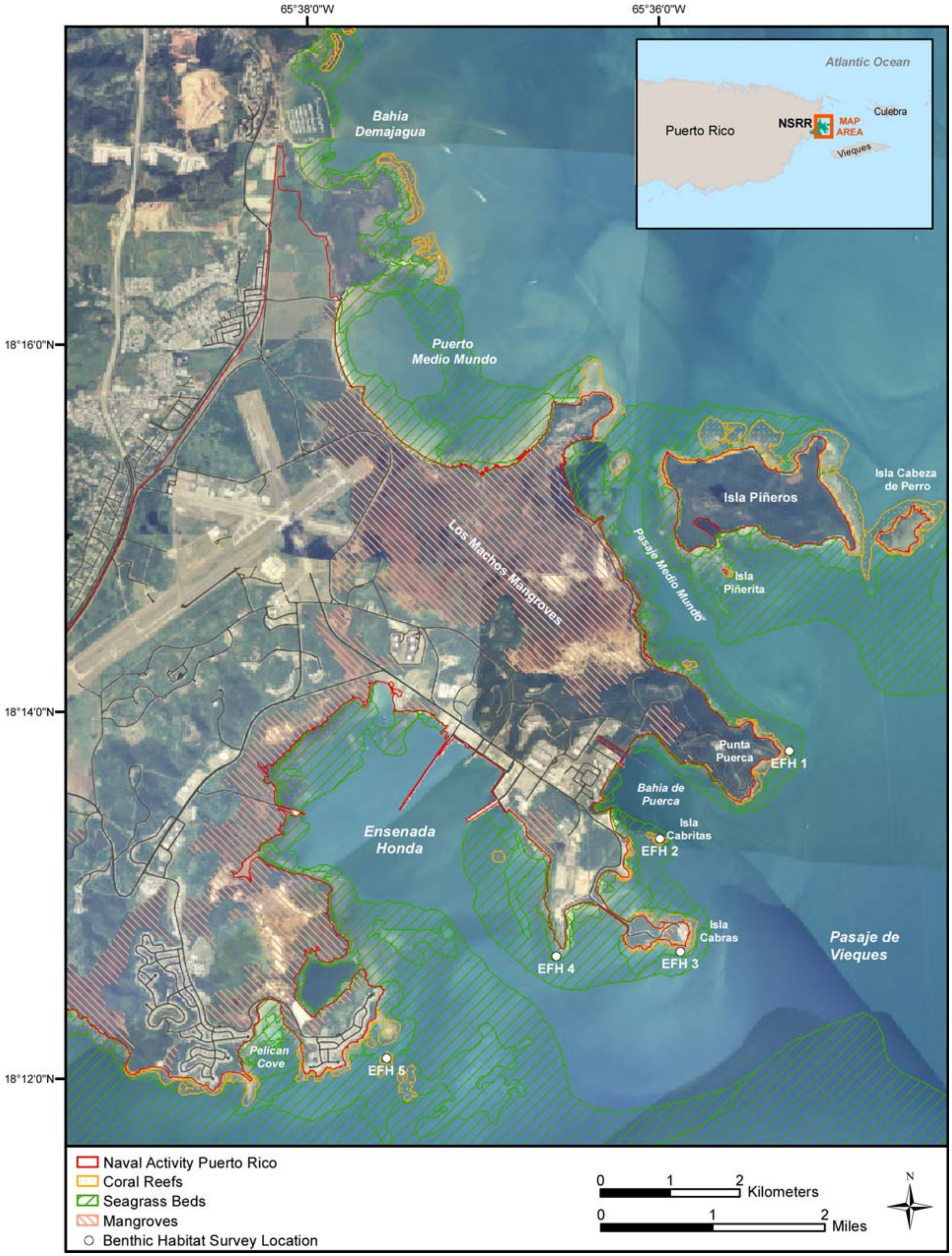

Figure 1. Location of Naval Activity Puerto Rico and reefs surveyed in 2004 (EFH 1-5).

of these sites revealed that the proposed site 4 was located in a large seagrass bed. No coral patch could be found in the area designated as a coral reef in the NOAA/NOS (2001) benthic habitat map. In agreement with the Naval Technical Representative, site 4 was relocated to the end of the northern peninsula of Ensenada Honda (**Figure 1**). Following is a review of the study sites:

Site 1 (EFH 1)–Located off Punta Puerca, this was a windward exposed site (**Figure 1**). Construction is planned on Punta Puerca (zone 7D; lodging and meetings facilities for the conference center). Water depth at this site was on average 17.5 feet (ft) (5.3 meters [m]). On the day of the survey (November 15, 2004), underwater horizontal visibility was reduced to approximately 5 ft (1.5 m), and there was a strong surface current (approximately > 2 knots [kt]) and continual wave action (approximately 5 ft, 1.5 m). The turbidity at this site was very high which prevented the quantitative stationary assessment of fishes which theoretically requires at least a 24 ft (7.5 m) horizontal visibility (Bohnsack and Bannerot 1986). The seafloor substrate was composed of coral and exposed rock.

Site 2 (EFH 2)–EFH 2 was located on the windward side of Isla Cabritas (**Figure 1**) at the entrance of Bahia Puerca. This site was surveyed on November 12, 2004. The survey was conducted on the slope of the fringing reef along the edge of Isla Cabritas. Average depth of the site was 14 ft (4.3 m). Underwater horizontal visibility at was low (approximately 15 ft, 5 m). The fringing reef substrate was composed of live and dead corals (dead *Acropora palmata* stands, dead *Montastraea faveolata* and *M. annularis*). There were large sea fans (*Gorgonia ventalina*), many of them had a moribund appearance. There were abundant macroalgae on the reef substrate. It was apparent that this site was subject to substantial sedimentation and turbidity.

Site 3 (EFH 3)–EFH 3 was a patch reef located in an embayment of the south side of Isla Cabras (**Figure 1**). The average water depth at EFH 3 was 9 ft (2.7 m). The site was surveyed on November 12, 2004. Horizontal visibility was approximately 15 ft (5 m). The seafloor was composed of small bare sediment patches and hard bottom substrate (including boulders, and coral substrate) interspersed with patches of seagrass (*Thalassia testudinum*). There were several live *A. palmata* stands remaining at this site. Large long-spined urchin (*Diadema antillarum*) were seen at this site.

Site 4 (EFH 4)–EFH 4 was a patch reef located at end of the northern peninsula of Ensenada Honda (**Figure 1**). The site was surveyed on November 15, 2004. Average water depth at this site was 7 ft (2.1 m). The underwater horizontal visibility was also limited at this site (10 to 15 ft, 3 to 5 m). This patch reef had developed on exposed rock. The reef was composed of live corals (mostly *M. annularis and M. faveolata*), abundant soft corals, abundant macroalgae and turf algae cover, and dead corals (*A. palmata* stands *and rubble*) was surrounded by seagrasses (mostly *T. testudinum*). Hard corals exhibited substantial partial mortality and mucus shedding (on *Porites astreoides*) (Lewis 1973; Rogers 1990; Nugues and Roberts 2003). This site was located adjacent to a former landfill located within NSRR Reuse Plan zone 7B.

Site 5 (EFH 5)–EFH 5 was a patch reef located at the end of the southern peninsula of Ensenada Honda, off of Punta Cascajo (NSRR Reuse Plan zone 5C) (**Figure 1**). The site was surveyed on November 13, 2004. Average water here was 8 ft (2.4 m). Horizontal visibility was limited to about 15 ft (5 m). The hard and soft coral cover at this site was established on exposed rock. The majority of the coral cover was made of small hard coral colonies and abundant soft corals (*G. ventalina*). There were a few large live *A. palmata* stands but most of the *A. palmata* was dead either still standing (rising from the seafloor to the sea surface) or as rubble. There was abundant macroalgae cover at this site. The most common hard coral at this site was *P. astreoides*. Two lobsters were seen on the patch reef. Fishing line was found entangled on the reef.

3.0 METHODS

The study sites were reached by boat (26 ft [7.9 m] GMI Explorer). The benthos and the reef fish populations were assessed at three replicate stations within each site. The replicate stations were established so as to maximize the cover of individual assessments (i.e., maximum site scatter and representativeness). We also measured water quality during the course of each of our surveys.

We navigated to the selected survey stations using a Trimble® ProXRS differential global positioning system (DGPS) unit (Trimble Navigation Ltd., Sunnyvale, CA) running Assess Surveyor 4.0. The OmniSTAR (Caribbean/ South American Service) real-time DGPS correction service was used to ensure accuracies of +/- 1.0 m (OmniSTAR, Inc. 2003). Once onsite, survey stations were geo-referenced. The DGPS positioning data were downloaded using Pathfinder Office 2.70 and exported into ESRI ArcGIS 8.2 Geodatabase data layers.

3.1 Benthic Surveys

The sessile benthos at each site was assessed using six 33 ft (10 m) long Linear Point Intercept (LPI) transects (Liddell and Ohlhorst 1987; Ohlhorst et al. 1988; Aronson and Precht 1995; Rogers et al. 1994) and six 6 ft (2 m) wide belt transects. Two LPIs and two belt transects were done at each sampling station.

An LPI transect consisted of a 10 m long surveyor's fiberglass measuring tape (marked at 1 cm intervals) loosely draped over the top surface of the reef. Each end of the tape was weighted down using a 1-lb lead ball. The six transects were haphazardly located about the reef immediately surrounding the sampling stations. A single observer recorded the identity of the sessile organism/substrate under equally spaced points (20 cm apart) along a line transect (measuring tape) for a total of 50 observations per transect. The percent cover of a given organism/substrate (PC_i) in a transect was equal to the ratio of the sum of observations for that particular organism/substrate (OB_i) and the total number of observations per transect (50).

$$PC_i = \frac{OB_i}{50}$$

Once the linear point intercept (LPI) survey was complete, the observer conducted a belt transect by swimming twice above the transect tape and recording all hard coral and echinoid species occurring within 1 m on either side of and at the end of the LPI transect (i.e., 23 square meters [m^2] area per transect). Hard coral species richness was estimated using the cumulative incidence of hard coral species within the belt transect.

3.2 Fish Surveys

The number and size of reef fishes were assessed using the stationary visual census technique (Bohnsack and Bannerot 1986) and the roving diver technique (Schmitt et al. 2002). We conducted 6 to 9 replicate stationary survey counts and 1-3 roving diver survey counts at each of 5 study sites.

We recorded all fish species observed during the five minute stationary surveys which were observed within an imaginary cylinder with a radius of 25 ft (7.5 m) from the observer. Immediately following the initial five minutes, additional time was used to record abundance (number of individuals per species) and total length (cm; minimum, maximum, and average) of the species observed during the first five minutes. Fish length was estimated using a calibrated T-shaped device (30 cm X 1 m) referred to as a "fish stick", constructed of ½" PVC tubing.

During roving diver surveys, the diver recorded species and estimated abundance while swimming haphazard transects through the study site for approximately 30 minutes. These haphazard transects were repeated 1 to 3 times per site. Fish abundance was categorized as either; single (one fish); few (2-10 fishes); many (11-100 fishes); and abundant (>100 fishes) (Schmitt et al. 2002). However, for this analysis only species presence/absence is analyzed as sightings per unit effort (SPUE). All species identifications (stationary and roving surveys) were based on Humann (1994) and Humann and DeLoach (2002).

For the stationary surveys, we used replicate count and size data to calculate the mean (standard deviation) number and size of each species by site. Stationary and roving diver data were converted to species presence/absence data and were used as SPUE for each survey method by site. SPUE represents the number of different species encountered within a 1 minute period.

3.3 WATER QUALITY

Water quality parameters were measured using a Hydrolab Datasonde 4a Multiprobe equipped with the Surveyor 4a waterproof display and Hydrolab Profiler software. The multiprobe was calibrated using required calibration standards and techniques. The sensor probe was placed on the reef within the three-buoy sampling station array. Selected parameters (i.e., temperature, specific conductivity, salinity, dissolved oxygen, pH, and turbidity) were measured every 20 minutes during the roughly two hours spent at each study site. Data were downloaded from the Hydrolab handheld data logger to a laptop computer using Hyper Terminal serial cable connection software.

4.0 RESULTS AND DISCUSSION

4.1 BENTHOS

Coral cover within the surveyed sites along NAPR was less than 10% (**Table 1; Figure 2**). Most of the benthic cover at these sites consisted of turf algae (cover range: 28 to 53%) and macroalgae (cover range: 9 to 35%) (**Table 1**). Mean coral cover on shallow reefs (3 to 16 ft, 1 to 5 m) in Puerto Rico is estimated at 16% and mean algal cover is estimated at 65% (Garcia et al. 2004). There were at least 23 species of corals along NAPR (**Table 2**). Most common coral taxa among sites observed on the linear point intercept transects were *Diploria strigosa*, *Porites astreoides*, and *Siderastrea siderea* (Table 2). Few observations of acroporids (*Acropora palmata*, *A. cervicornis*, *A. prolifera*) were observed within the belt transects. The most abundant coral taxon observed under the linear point intercept transects was *P. astreoides*. Sites with the most coral diversity based on the linear point intercept data were EFH 3 and EFH 4 with eight and ten coral taxa, respectively. Except for sites EFH 3, gorgonian cover was higher than coral cover (cover range: 8 to 25%) (**Table 1**). Characteristics of these NAPR sites are similar to the average shallow coral ref site described by Garcia et al. (2004).

The long-spined urchin, *Diadema antillarum*, was observed under the line point intercept at two of the nine sites (EFH 3 and EFH 4). Belt transects showed that there were on average 0 to 0.24 *D. antillarum* per square meter *(*m^{-2}) and 0 to 0.14 *Echinometra* spp. m^{-2} (**Figures 3 and 4**). While *D. antillarum* is not completely absent at the study sites, densities remain very low compared with areas where it is making a come back (~ 5 individuals/m^2 in northern Jamaica; Edmunds and Carpenter 2001).

Table 1. Mean percent cover of benthic taxa and substrates at sites EFH 1 to 5 along NAPR as recorded in replicate 33 ft (10 m) long line point intercept transects.

Taxon/Substrate	EFH 1	EFH 2	EFH 3	EFH 4	EFH 5
Turf Algae	28.0	32.3	40.3	52.7	53.0
Crustose Algae	0.0	0.0	0.3	0.0	0.0
Macroalgae	9.0	35.7	19.7	24.0	27.3
Seagrass	0.0	0.0	17.3	0.3	0.0
Sponge	20.3	1.7	0.3	2.0	1.7
Coral	4.3	4.0	10.3	6.7	4.0
Gorgonian	24.7	10.7	5.7	11.7	8.3
Zoanthid	4.7	0.0	0.0	0.0	0.3
Diadema antillarum	0.0	0.0	0.3	0.3	0.0
Sand	9.0	15.7	5.7	2.3	5.3

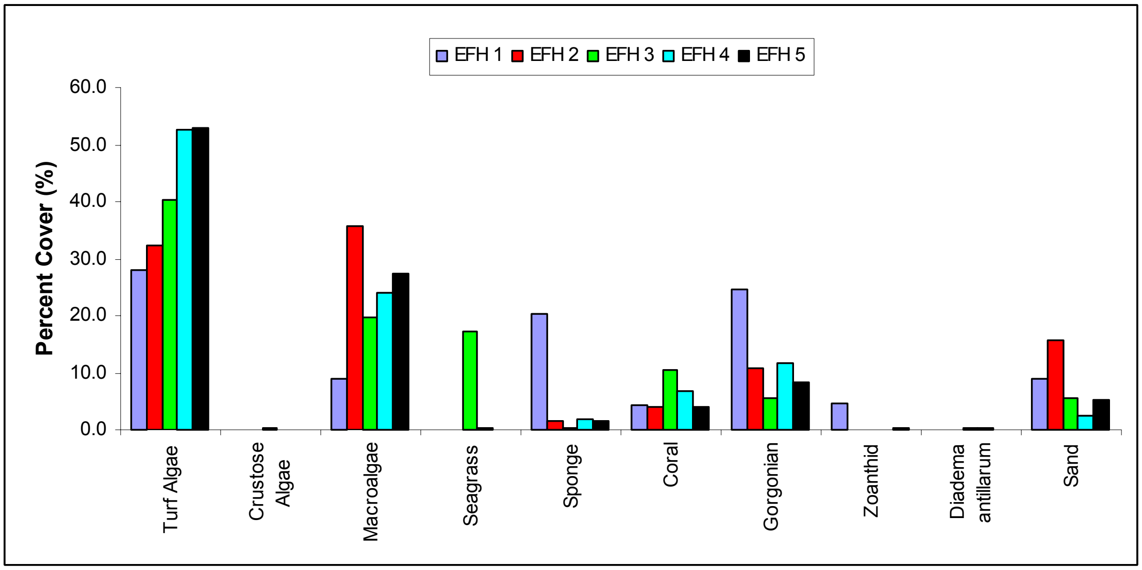

Figure 2. Composition of the benthos (taxa and substrates) at five nearshore sites along NAPR as recorded in 2004 along replicate 33 ft (10 m) long line point intercept transects.

Table 2. Coral taxa found within linear point intercept transects and belt transects at sites EFH 1 to 5 along NAPR in 2004.

Coral taxa	**EFH1**	**EFH2**	**EFH3**	**EFH4**	**EFH5**
Acropora cervicornis	X				
Acropora palmata			X	X	
Acropora prolifera			X		
Agaricia spp.	X	X	X	X	X
Dichocoenia stokesii	X			X	
Diploria clivosa			X	X	X
Diploria labyrinthiformis		X			
Diploria strigosa	X	X	X	X	
Eusmilia fastigiata		X			
Favia fragum	X	X	X	X	X
Meandrina meandrites	X				
Millepora spp.	X	X	X	X	
Montastraea annularis		X	X	X	
Montrastraea cavernosa	X	X	X	X	X
Montastraea faveolata	X	X	X	X	
Montastraea franksi	X	X	X	X	X
Mycetophyllia lamarkiana					X
Porites astreoides	X	X	X	X	X
Porites porites	X	X	X	X	X
Scolymia cubensis		X			
Siderastrea radians	X			X	
Siderastrea siderea	X	X	X	X	X
Stephanocoenia michelini		X			
Total	14	15	14	15	9

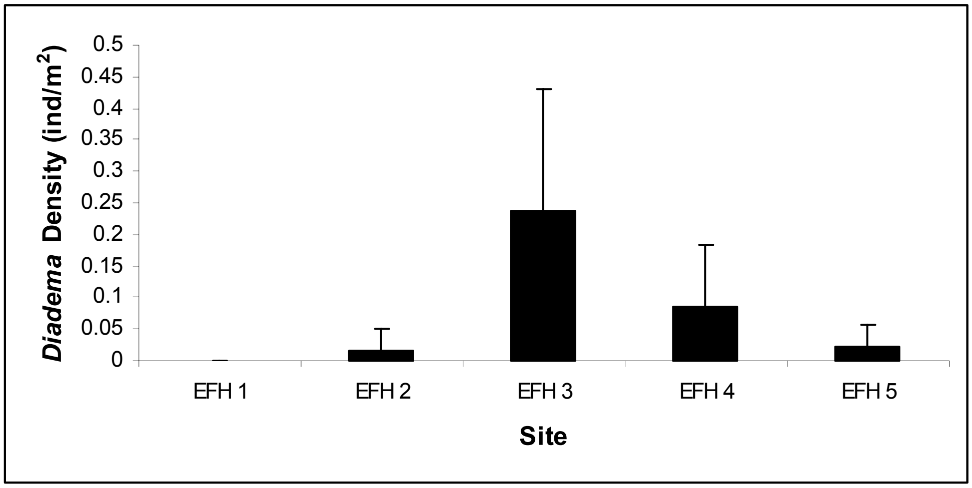

Figure 3. Density of *Diadema antillarum* within 6 ft (2 m) wide belt transects at sites EFH 1-5 along NAPR in 2004.

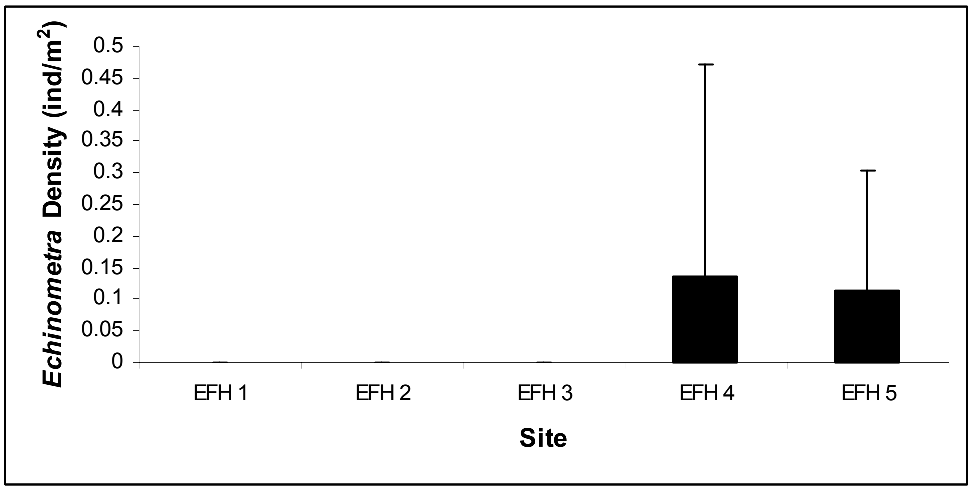

Figure 4. Density of *Echinometra spp.* within 6 ft (2 m) wide belt transects at sites EFH 1to 5 along NAPR in 2004.

Coral reefs in the NAPR and vicinity are potentially exposed to the following sources of human-induced threats that compound natural changes on reefs (including hurricane impacts): overfishing, polluted runoff (including sewage, pesticides), coastal development, upland deforestation, anchoring, and destructive fishing techniques (Sullivan-Sealy and Bustamante 1999; Causey et al. 2000; Garcia et al. 2004). These sources of impact can or already have led to the serious deterioration of coral reef habitat and structure in reefs of Puerto Rico and the Virgin Islands as a result of nutrification, sedimentation, and mechanical damages to corals (Sullivan-Sealy and Bustamante 1999; Causey et al. 2000; Garcia et al. 2004). Upland deforestation and the resulting sedimentation on fringing reefs (closest to shore) are thought to be the most significant threat to coral reefs in this area (CFMC 2004).

The CFMC established a FMP to restrict the taking of coral reef resources within Puerto Rico and the U.S. Virgin Island's Exclusive Economic Zone (EEZ). The Coral FMP prohibits the harvest, possession, or sale of stony corals, sea fans, gorgonians, and other species attached to live-rock as well as the use of chemicals, toxins, or explosives to harvest any species (CFMC 2004). More than 100 species of coral and over 60 species of algae, seagrasses, and invertebrates are protected by the Coral FMP (CFMC 2004).

The nearshore reefs and hard bottom areas adjacent to Puerto Rico and the U.S. Virgin Islands (USVI) are designated as habitat areas of particular concern (HAPC) because of their fishery value.

Human-induced stressors that impact the north and south coastal environments of Puerto Rico include water quality changes (increased terrigenous sediment input and increased nutrient/sewage input), coastal habitat loss caused by development, uncontrolled recreational activities, and the decline in species abundance (from overfishing) (Hernández-Delgado and Sabat 1998; Sullivan-Sealey and Bustamante 1999; Causey et al. 2000; Morelock et al. 2001).

The main naturally induced impacts on coral reefs are caused by hurricanes, storm damage, silt-laden runoff following heavy rainfall/floods, the Caribbean-wide morality of the long-spined urchin in the 1980s, repeated coral bleaching events of the 1980s, and widespread coral diseases (Glynn et al. 1964; Goenaga and Canals 1990; Bruckner and Bruckner 1997; Causey et al. 2000; Morelock et al. 2001; Gardner et al. 2003). The additive pressures of naturally occurring and anthropogenic stresses have led to the critical status of Puerto Rican coral reefs (100% at risk; Spalding et al. 2001).

4.2 Reef Fishes

Approximately 9 hours of reef fish survey effort was conducted at four of five EFH sites resulting in the identification of 75 species belonging to 25 families of fish (**Table 3**). Seven species sighted during both censuses are species managed by the Reef Fish FMP and include: squirrelfish, *Holocentrus adscensionis*; schoolmaster, *Lutjanus apodus*; yellowtail snapper, *Ocyurus chrysurus*; banded butterflyfish, *Chaetodon striatus*;white grunt, *Haemulon plumieri*; redtail parrotfish, *Sparisoma chrysopterum*; and scrawled cowfish, *Acanthostracion quadricornis* (**Table 3**). Site EFH 1 was not surveyed quantitatively due to poor visibility. Number of species sighted for each survey type varied by location and technique. Overall, the greatest number of species were seen at site EFH 5 (79) followed by site EFH 3 (77). The numbers of species seen in stationary surveys were low, ranging from 20 at site 2 to 33 at site EFH 5. Alternatively, the numbers of species seen in roving diver surveys ranged from 25 at site EFH 2 to 52 at site EFH 3 (**Figure 5**).

Table 3. List of reef fish species sighted in the stationary and roving diver surveys. Species in **bold** are managed under the Reef Fish Fishery Management Plan by the Caribbean Fisheries Management Council.

Family	Species	Common Names
SYNODONTIDAE	*Synodus intermedius*	Sand diver
HOLOCENTRIDAE	*Holocentrus adscensionis*	**Squirrelfish**
	Holocentrus coruscus	Reef squirrelfish
	Holocentrus rufus	Longspine squirrelfish
	Myripristis jacobus	Blackbar soldierfish
AULOSTOMIDAE	*Aulostomus maculatus*	Trumpetfish
SERRANIDAE	*Cephalopholis cruentata*	Graysby
	Hypoplectrus nigricans	Black hamlet
	Hypoplectrus puella	Barred hamlet
	Hypoplectrus sp.	Hybrid hamlet sp.
GRAMMATIDAE	*Gramma loreto*	Fairy basslet
PRIACANTHIDAE	*Priacanthus cruentatus*	Glasseye snapper

Table 3. Continued

Family	Species	Common Names
LUTJANIDAE	*Lutjanus apodus*	**Schoolmaster**
	Lutjanus jocu	Dog snapper
	Lutjanus mahogoni	Mahogany snapper
	Ocyurus chrysurus	**Yellowtail snapper**
GERREIDAE	*Gerres cinereus*	Yellowfin mojarra
HAEMULIDAE	*Anisotremus surinamensis*	Black margate
	Anisotremus virginicus	Porkfish
	Haemulon carbonarium	Caesar grunt
	Haemulon chrysargyreum	Smallmouth grunt
	Haemulon flavolineatum	French grunt
	Haemulon melanurum	Cottonwick
	Haemulon parra	Sailors choice
	Haemulon plumieri	**White grunt**
	Haemulon sciurus	Bluestriped grunt
SPARIDAE	*Archosargus probatocephalus*	Sheepshead
SCIAENIDAE	*Equetus acuminatus*	Highhat
	Odontoscion dentex	Reef croaker
MULLIDAE	*Mulloidichthys martinicus*	Yellow goatfish
	Pseudupeneus maculatus	Spotted goatfish
CHAETODONTIDAE	*Chaetodon capistratus*	Foureye butterflyfish
	Chaetodon striatus	**Banded butterflyfish**
POMACANTHIDAE	*Holacanthus tricolor*	Rock beauty
	Pomacanthus arcuatus	Gray angelfish
	Pomacanthus paru	French angelfish
CARANGIDAE	*Caranx ruber*	Bar jack
POMACENTRIDAE	*Abudefduf saxatilis*	Sergeant major
	Microspathodon chrysurus	Yellowtail damselfish
	Stegastes diencaeus	Longfin damselfish
	Stegastes dorsopunicans	Dusky damselfish
	Stegastes leucostictus	Beaugregory
	Stegastes partitus	Bicolor damselfish
	Stegastes planifrons	Threespot damselfish
	Stegastes variabilis	Cocoa damselfish

Table 3. Continued

Family	Species	Common Names
LABRIDAE	*Bodianus pulchellus*	Spotfin hogfish
	Bodianus rufus	Spanish hogfish
	Halichoeres bivittatus	Slippery dick
	Halichoeres caudalis	Painted wrasse
	Halichoeres maculipinna	Clown wrasse
	Halichoeres poeyi	Blackear wrasse
	Halichoeres radiatus	Puddingwife
	Lachnolaimus maximus	Hogfish
	Thalassoma bifasciatum	Bluehead
SCARIDAE	*Scarus iseri*	Striped parrotfish
	Scarus taeniopterus	Princess parrotfish
	Sparisoma aurofrenatum	Redband parrotfish
	Sparisoma chrysopterum	**Redtail parrotfish**
	Sparisoma rubripinne	Yellowtail parrotfish
	Sparisoma viride	Stoplight parrotfish
BLENNIIDAE	*Malacoctenus triangulatus*	Saddled blenny
	Ophioblennius atlanticus	Redlip blenny
GOBIIDAE	*Coryphopterus eidolon*	Pallid goby
	Gnatholepis thompsoni	Goldspot goby
	Gobiosoma genie	Cleaning goby
ACANTHURIDAE	*Acanthurus bahianus*	Ocean surgeonfish
	Acanthurus chirurgus	Doctorfish
	Acanthurus coeruleus	Blue tang
MONOCANTHIDAE	*Monacanthus tuckeri*	Slender filefish
TETRAODONTIDAE	*Canthigaster rostrata*	Sharpnose puffer
	Sphoeroides spengleri	Bandtail puffer
OSTRACIIDAE	*Acanthostracion quadricornis*	**Scrawled cowfish**
	Lactophrys bicaudalis	Spotted trunkfish
	Lactophrys triqueter	Smooth trunkfish
DIODONTIDAE	*Diodon hystrix*	Porcupinefish

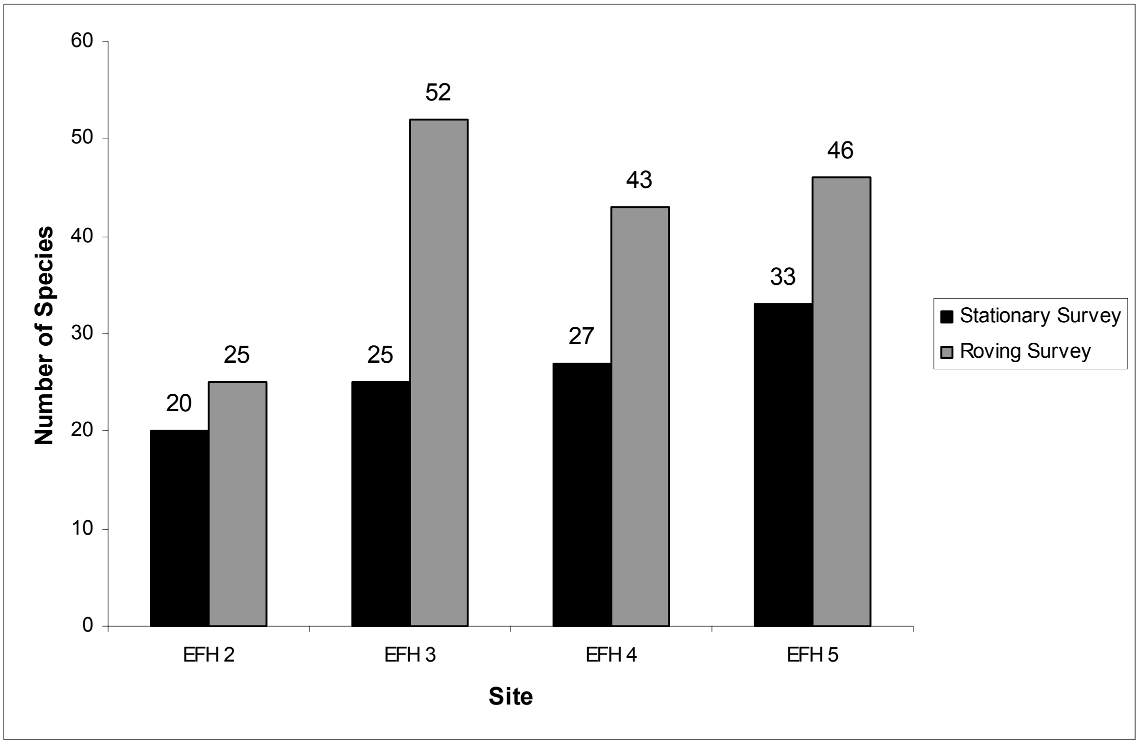

Figure 5. Number of reef fish species surveyed using the stationary and roving methods at sites EFH 2 to 5. Effort for the roving survey was not equitable among sites. Site EFH 1 was not surveyed due to high turbidity.

Stationary Fish Counts–Nine replicate, five minute reef fish stationary counts were conducted at sites EFH 4 and EFH 5, however only six replicates were completed at sites EFH 2 and EFH 3 due to time constraints. No stationary surveys were completed at site EFH 1 because of high turbidity. Fifty-two species of fish were observed among the four sites (**Table 4**). Numbers of individuals of each species were highly variable and ranged from single sightings for multiple species to 10 individuals for the dog snapper, dusky damselfish and the striped parrotfish. Mean size was also variable with the largest fish, dog snapper, being 25 cm long. Mean fish numbers and lengths are summarized by species in Table 4. SPUE is defined here as the number of species seen within a one minute period (**Figure 6**). SPUE for the stationary surveys varied from 0.6 to 0.83.

Roving Diver Censuses–Five hours of survey were dedicated to roving diver surveys and observed 65 species across the four sites (**Table 5**). Survey effort was not equitable across sites. Sites 3-5 had 3 replicate, 30 minute surveys with site 2 only being surveyed once. Due to the inequitable survey effort, SPUE for the roving diver surveys were adjusted to the number of species seen in a one minute period. SPUE values were very close to 1 and ranged from 0.8 to 0.93 (**Figure 7**).

Table 4. Number of reef fish (n) of each species observed at sites EFH 2-5 during 5 minute observation periods. Site EFH 1 was not surveyed due to high turbidity. Number of observation periods was six for sites EFH 2 and EFH 3; and nine for sites EFH 4 and EFH 5. Mean number ($\bar{x}$) and standard deviation (SDn) was calculated. Size of fish was estimated to the nearest 0.5 cm and when possible a mean ($\bar{x}$) and standard deviation (SDs) was calculated. Species in **bold** are managed under the Reef Fish Fishery Management Plan by the Caribbean Fisheries Management Council.

Species	**Site**			
	2	**3**	**4**	**5**
Gray Angelfish				
n	3	1	1	2
meann	1	1	1	1
SDn	0	0	0	0
means	12	12	12	12.5
SDs	5.29	0	0	3.54
Rock Beauty				
n		1		
meann		1		
SDn		0		
means				
SDs				
Fairy Basslet				
n		2		
meann		1		
SDn		0		
means		2		
SDs		0		
Scrawled Cowfish				
n				1
meann				1
SDn				0
means				8
SDs				0
Sharpnose Pufferfish				
n	1		3	2
meann	1		1	1
SDn	0		0	0
means	6		2	1.5
SDs	0		0	0.71
Smooth Trunkfish				
n			1	
meann			1	
SDn			0	
means			1	
SDs			0	

Table 4. Continued

Species	**Site**			
	2	**3**	**4**	**5**
Four-eyed Butterfly				
n	1	1		6
meann	1	1		3
SDn	0	0		2.83
means				
SDs				
Banded Butterfly				
n		1		
meann		1		
SDn		0		
means		4		
SDs		0		
Reef Croaker				
n				1
meann				1
SDn				0
means				10
SDs				0
Threespot Damselfish				
n	14	23	6	2
meann	2.8	2.88	3	1
SDn	1.79	1.46	2.83	0
means	4.8	3.5	5.13	5
SDs	3.11	0.71	0.99	0
Damselfish				
n	1	10		
meann	1	3.33		
SDn	0	1.53		
means	5	3.33		
SDs	0	0.58		
Beaugregory				
n	1	1	9	
meann	1	1	1.8	
SDn	0	0	0.45	
means	5		3.1	
SDs	0		0.55	
Bicolor Damselfish				
n	1			
meann	1			
SDn	0			
means	3			
SDs	0			

Table 4. Continued

Species	Site			
	2	**3**	**4**	**5**
Cocoa Damselfish				
n				2
meann				2
SDn				0
means				5
SDs				0
Dusky Damsel				
n		1	13	36
meann		1	6.5	5.14
SDn		0	4.95	1.46
means		4	4.5	3.86
SDs		0	0.71	0.9
Longfin Damselfish				
n	8			4
meann	4			4
SDn	4.24			0
means	8.5			5
SDs	2.12			0
Sargent Major				
n		6		
meann		3		
SDn		1.41		
means		5		
SDs		0		
Yellowtail Damselfish				
n	3	1	4	10
meann	1.5	1	1.33	1.43
SDn	0.71	0	0.58	0.53
means	7		8.67	3.86
SDs	7.07		1.53	2.12
Spotted Goatfish				
n		1		
meann		1		
SDn		0		
means				
SDs				
Graysby				
n	1			
meann	1			
SDn	0			
means	15			
SDs	0			

Table 4. Continued

Species	**Site**			
	2	**3**	**4**	**5**
Blue-Striped Grunt				
n				2
meann				2
SDn				0
means				7
SDs				0
French Grunt				
n		3		2
meann		1		2
SDn		0		0
means		9.5		6.5
SDs		0.71		0.71
Bar Jack				
n		1		1
meann		1		1
SDn		0		0
means		8		6
SDs		0		0
Yellowfin Moharra				
n				1
meann				1
SDn				0
means				12
SDs				0
Princess Parrotfish				
n	29	8	14	2
meann	5.8	4	3.5	2
SDn	1.3	1.41	1	0
means	4	2.5	3.5	2
SDs	0.71	0.71	1	0
Red Banded Parrotfish				
n	4		1	
meann	1.33		1	
SDn	0.58		0	
means	14.67		10	
SDs	5.77		0	
Redtail Parrotfish				
n		1	1	6
meann		1	1	1.5
SDn		0	0	0.58
means		7.5	6	7
SDs		0.71	0	3.83

Table 4. Continued

Species	Site			
	2	**3**	**4**	**5**
Stop Light Parrotfish				
n	1	8	21	9
meann	1	2	2.62	1
SDn	0	2	0.92	0
means	4	3.67	4.5	5.44
SDs	0	0.58	0.93	4.07
Striped Parrotfish				
n	8	20	13	1
meann	4	6.67	4.33	1
SDn	3.83	2.89	0.58	0
means	4.5	2	3	4
SDs	0.71	0	0	0
Yellowtail Parrotfish				
n		5	1	5
meann		2.5	1	1
SDn		2.12	0	0
means		5.5	10	6.8
SDs		3.54	0	2.77
Sheepshead				
n		1		
meann		1		
SDn		0		
means				
SDs				
Barred Hamlet				
n	2		2	
meann	1		1	
SDn	0		0	
means	8.5		5.5	
SDs	4.95		0.71	
Black Hamlet				
n	2		2	
meann	2		1	
SDn	0		0	
means	8		6	
SDs			0	
Hamlet				
n				1
meann				1
SDn				0
means				4
SDs				0

Table 4. Continued

Species	**Site**			
	2	**3**	**4**	**5**
Dog Snapper				
n				10
meann				10
SDn				0
means				25
SDs				0
Glass-eyed Snapper				
n	1			
meann	1			
SDn	0			
means	15			
SDs	0			
Mahogany Snapper				
n			1	
meann			1	
SDn			0	
means			10	
SDs			0	
Schoolmaster				
n			3	12
meann			1.5	2.4
SDn			0.71	2.19
means			9	7.8
SDs			1.41	0.84
Yellowtail Snapper				
n	1			
meann	1			
SDn	0			
means	10			
SDs	0			
Longspine Squirrelfish				
n			5	1
meann			1.67	1
SDn			1.15	0
means			9.33	10
SDs			2.31	0
Squirrelfish				
n		1	1	3
meann		1	1	1.5
SDn		0	0	0.71
means		7	10	9
SDs		0	0	2.83

Table 4. Continued

Species	Site			
	2	**3**	**4**	**5**
Blue Tang				
n		1	8	9
meann		1	1.6	1.5
SDn		0	0.55	0.84
means		1	4	3.67
SDs		0	2.24	1.21
Doctorfish				
n			3	2
meann			1	2
SDn			0	0
means			5	4.67
SDs			2	0.58
Ocean Surgeonfish				
n		10	9	19
meann		1.25	1.8	2.38
SDn		0.46	0.84	0.92
means		5	5.2	4.56
SDs		2.83	2.17	1.29
Trumpetfish				
n			1	1
meann			1	1
SDn			0	0
means			20	15
SDs			0	0
Blue Headed Wrasse				
n	1	6	9	9
meann	1	1.5	2.25	2.25
SDn	0	0.58	1.5	1.26
means	8	2.25	2.5	4
SDs	0	0.96	0.58	0.82
Clown Wrasse				
n			11	8
meann			2.75	4
SDn			1.71	4.24
means			4.5	5.5
SDs			1.73	0.71
Hogfish				
n			1	
meann			1	
SDn			0	
means			10	
SDs			0	

Table 4. Continued

Species	Site			
	2	**3**	**4**	**5**
Painted Wrasse				
n			1	5
meann			1	5
SDn			0	0
means			7	3
SDs			0	0
Slippery Dick				
n	2	8		1
meann	2	2		1
SDn	0	2		0
means	6	6.33		2
SDs	0	5.13		0
Spanish Hogfish				
n				1
meann				1
SDn				0
means				5
SDs				0
Spotfin Hogfish				
n				1
meann				1
SDn				0
means				4
SDs				0

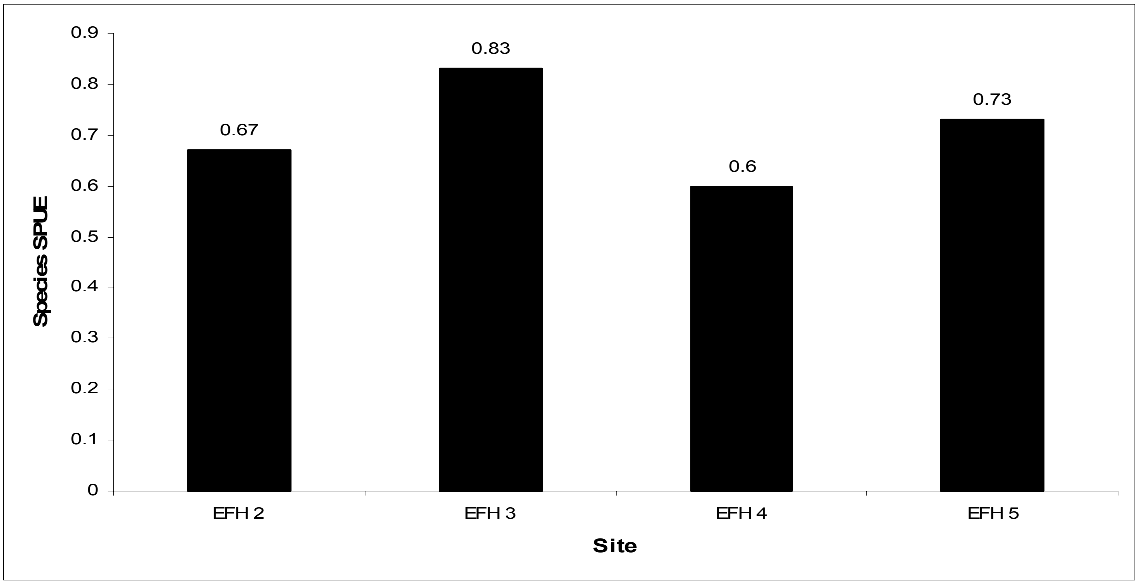

Figure 6. Number of reef fish species sighted per minute or SPUE (sightings-per-unit-effort) from the 5 minute stationary surveys for sites EFH 2 to 5. Site EFH 1 was not surveyed due to high turbidity.

Table 5. Reef fish species presence/absence data collected during each 30 minute roving diver transect survey. Three replicates were done for sites EFH 3 to 5, site EFH 1 was not surveyed due to high turbidity. Species in **bold** are managed under the Reef Fish Fishery Management Plan by the Caribbean Fisheries Management Council.

Common name	2.1	3.1	3.2	3.3	4.1	4.2	4.3	5.1	5.2	5.3
French angelfish	X		X	X						X
Gray angelfish				X					X	
Redlip blenny		X		X		X		X		
Saddled blenny				X						
Smooth trunkfish		X				X		X		
Spotted trunkfish				X	X					X
Banded butterflyfish			X		X					
Foureye butterflyfish		X			X	X		X	X	
Cocoa damselfish	X				X				X	
Dusky damselfish				X		X	X			X
Longfin damselfish	X	X		X	X	X		X	X	
Sergeant major			X	X		X				
Threespot damselfish	X						X			
Yellowtail damselfish	X		X	X	X	X		X	X	X
Highhat							X			X
Reef croaker		X						X		
Slender filefish			X							
Spotted goatfish			X	X	X		X			
Yellow goatfish		X	X	X	X			X	X	X
Goldspot goby	X									
Pallid goby	X									
Cleaning goby		X				X		X		
Graysby		X						X		

Table 5. Continued

Common name	2.1	3.1	3.2	3.3	4.1	4.2	4.3	5.1	5.2	5.3
Bluestriped grunt	X				X					X
Caesar grunt		X		X				X		X
Cottonwick										
French grunt	X	X	X	X		X		X		X
Black margate								X		X
Porkfish		X				X		X	X	
Sailors choice										
Smallmouth grunt				X		X				X
White grunt		X					X	X		
Barred hamlet	X	X			X		X	X		
Black hamlet	X									X
Hybrid hamlet sp.				X		X				
Spanish hogfish		X		X				X		
Bar jack	X			X			X			
Princess parrotfish	X	X			X	X	X	X		
Redband parrotfish	X	X	X	X	X	X	X	X	X	X
Stoplight parrotfish	X	X	X	X	X	X		X	X	X
Striped parrotfish	X	X	X	X	X	X	X	X		
Redtail parrotfish		X								
Yellowtail parrotfish		X	X		X		X	X	X	X
Bandtail puffer			X							
Porcupinefish	X	X						X		
Sharpnose puffer	X		X		X		X		X	X
Dog snapper		X			X			X		X
Mahogany snapper		X		X				X		
Schoolmaster	X	X	X	X	X		X	X		X
Yellowtail snapper		X			X		X	X		X
Blackbar soldierfish		X		X		X		X		
Longspine squirrelfish	X		X	X		X	X		X	
Squirrelfish				X						X
Reef squirrelfish										X
Blue tang	X	X	X	X	X	X	X	X	X	X
Doctorfish	X		X	X	X	X			X	X
Ocean surgeonfish				X	X	X	X			X
Bluehead wrasse		X	X	X	X	X	X	X	X	X
Clown wrasse						X				
Puddingwife				X	X	X	X		X	X
Slippery dick	X	X	X	X	X	X		X		
Blackear wrasse			X			X				
Glasseye snapper	X									
Sand diver	X			X	X		X			
Trumpetfish		X		X				X		X

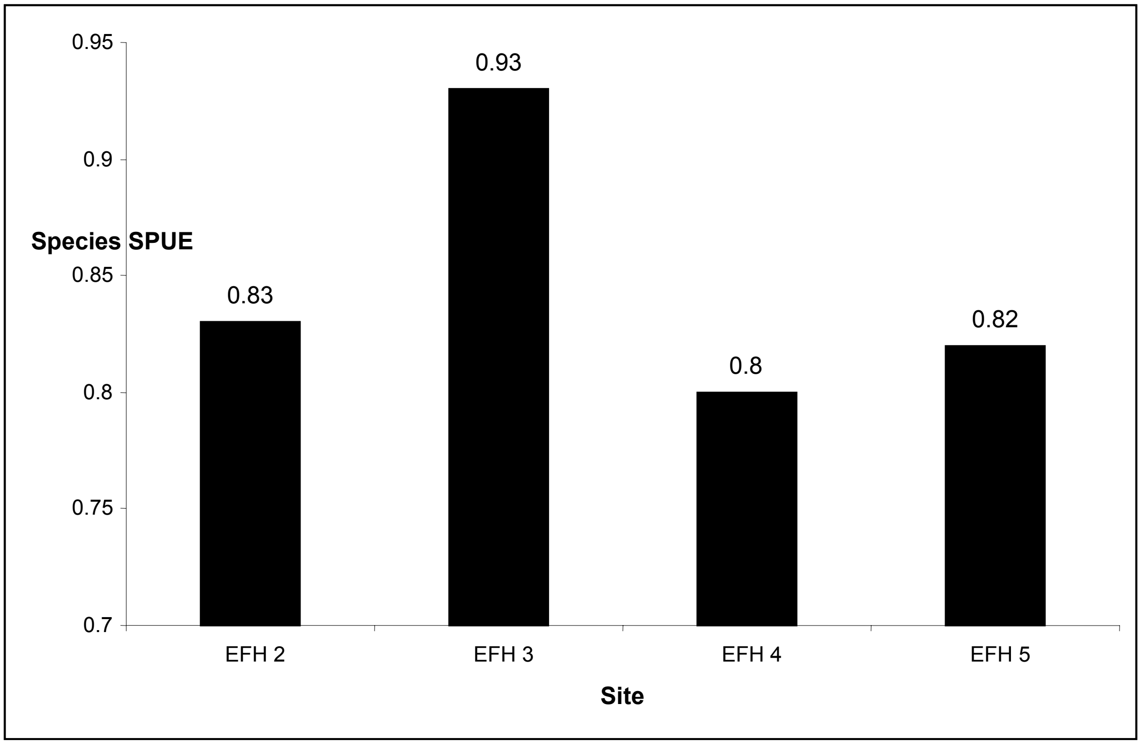

Figure 7. Number of reef fish species sighted per minute or SPUE (sightings-per-unit-effort) from 30 minute roving diver surveys for sites EFH 2 to 5. Site EFH 1 was not surveyed due to high turbidity.

5.0 CONCLUSIONS

This REA characterized reef sites along the NAPR shoreline and proposed reuse and development sites (CBRE 2004). The reefs along NAPR were in poor condition as characterized by low coral cover, low coral diversity, high turf algae cover, high macroalgae cover, abundant occurrence of diseased and moribund sea fans (*Gorgonia ventalina*, abundant coral mortality (skeletons of *A. palmata* and *M. faveolata*, and *M. annularis*), a very limited fish population, and the presence of very few echinoids. Further, during the 2004 survey of benthic communities along NAPR it became apparent that the reefs have been exposed to both the local and the regional runoff and associated sedimentation and turbidity. Heavy rainfall that occurred during the 2004 survey combined with strong winds out of the northeast allowed for the observation of local dispersion of sediment-laden runoff, the advection of turbid water from river and storm runoff from areas north of NAPR (Bahia Demajagua), and the tidal effects on the local transport of turbid waters. It appeared that naturally occurring disturbances on the reefs (including runoff and exposure) were exacerbated by the dispersion of newly-generated sediments and the resuspension of existing sediments on the seafloor. Therefore, the existing reefs along NAPR are currently under stress from existing naturally-occurring and human-induced disturbances.

Proposed activities that may have adverse short-term and long-term effects on coral reefs along NAPR are those that will alter coastal water quality, increase terrestrial runoff, cause excessive sedimentation, cause nutrient enrichment, and cause physical impacts (Rogers 1990; McCook 1999; Szmant 2002; Nugues and Roberts 2003; Thrush et al. 2004; Fabricius 2004).

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